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RADIATIONS AND CELL DIVISION

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INTRODUCTION

THE discovery in 1903 that actively dividnig cells such as occur in malignant tumors can be selectively affected by radium emanations and x-rays excited the imagination of the biologist as well as that of the clinician. Not only did this offer a possible cure for cancer but it also provided a tool which was to be used extensively for the investigation of cell division, regeneration, and related problems. The work on these short radiations has led naturally to curiosity about the effects of other parts of the spectrum upon cell division, and an extensive but scattered literature has developed. This work, taken as a whole, gives some insight into the complex problem of cell division as well as considerable information as to the way in which radiations act upon organisms. It is the purpose of this review mainly to cover the newer literature. References to older papers or books will be made only when such are necessary for completeness or continuity. A brief discussion of the nature and measurement of the various radiations will precede the discussion of their effects on cell division. Other effects will be referred to whenever their inclusion may help the reader to reach decisions on controversial issues.

The electromagnetic spectrum

The electromagnetic spectrum, consisting of the whole gamut of radiations which travel with the speed of light, is divided into various regions on the basis of source or visibility. No exact limit can be set to the different regions of the spectrum but arbitrary divisions are given in Table 1. Besides these radiations, radioactive emanations and neutrons are also used in biological experimentation. The former consist of gamma rays and alpha and beta particles; neutrons are uncharged particles of the mass of a proton, experimentally produced by the impact of greatly accelerated protons or deuterons in a magnetic field striking the target in a cyclotron (Glasser et al., 1944). Absorption of neutrons results in the liberation of recoil protons which produce intense ionization along their paths (Lawrence and Lawrence, 1946).

For accurate and reproducible studies it is necessary to know the intensity of the radiations used. Intensities of radiations in different parts of the spectrum may be measured by determining the heat produced when the radiations are absorbed, but in some cases, as discussed below, other effects of radiation are found more convenient. In the radio wave region, heating of salt solutions has been used as a measure of the strength of the field (McClennan and Burton, 1930, 1931). Infrared, visible and ultraviolet radiations can be measured accurately by instruments (such as thermopiles or bolometers) equally sensitive to all wavelengths and calibrated against standards of known intensity (Forsythe, 1937). However, photocells and photoelectric cells, although differentially sensitive at different wavelengths, are most frequently used in this part of the spectrum because of their sensitivity and greater convenience. They must be

calibrated against thermopiles or bolometers and their sensitivities at different wavelengths determined. In the x-ray region, ionization in air is used, the unit being the roentgen, which is defined as "the quantity of x or γ radiation such that the associated corpuscular emission per 0.001293 g. of air produces, in air, ions carrying 1 electrostatic unit of quantity of electricity of either sign.... It corresponds to the liberation of 2.082×10^9 ion pairs per cm^3 of air at standard conditions" (Lea, 1947, p. 6–7). This unit is actually a dose rate and not an intensity unit. The absorption per unit volume for the same intensity of radiation is 1000 times greater in tissue than in air on account of the greater density of the tissue. Beta particles, alpha particles, and protons may be measured in roentgens by an extension of the definition for x-rays, the roentgen being defined as that dose "which liberates in 0.001293 g. of air ions carrying 1 e.s.u. of charge" (Lea, 1947, p. 18). Gray defines the neutron dose at a point as "1 ν when the associated corpuscular radiations produced in water liberate in air 1 e.s.u. of charge of either sign per 0.001293 g. of air" (Lea, 1947, p. 2). The "n" or neutron unit often measured with a Victoreen ionization chamber is usually taken to be equal to 2.5 ν units. For a discussion of the difficulties of comparing these various radiations, see Lea (1947, chapter 1).

Long and short radiations are absorbed in different ways by matter; thus infrared, visible, and ultraviolet radiations are absorbed by specific atomic configurations in the molecules known as *chromophores* (see Miller, 1940; Brode, 1941). In the visible spectrum absorption by such chromophores results in color. In the cell the chief ultraviolet chromophores are the purine and pyrimidine bases in the nucleoproteins and the aromatic amino acids in the unconjugated proteins.

In contrast to the specific absorption in infrared, visible, and ultraviolet light depending on chemical structure, the absorption of ionizing radiations depends upon a physical property—the density of the substance. An x-ray photon gives its energy to an electron, and this in turn transfers energy. For each 32.5 electron volts an ion pair is formed (x and γ rays; 35 volts for α particles). The range of the primary photoelectron is directly proportional to its initial velocity and inversely proportional to the density of the substance. An excellent account of the problems of measuring ionizing radiations, the ranges of ionizing particles in tissue, and the density of ionization in tissue, as well as the chemical reactions which follow ionization, will be found in Lea's book (1947, chapters 1 and 2).

TABLE 1

The electromagnetic spectrum

(from several sources)

REGION	SUBDIVISION	WAVELENGTH
γ (gamma) rays	(radioactivity)	0.005–10 A
X-rays	hard—deep therapeutic	0.01–0.08 A
	hard—diagnostic	0.12–0.30 A
	soft (grenz)—skin therapy	1.0–5.0 A
	soft—experimental	5.0–200 A
Ultraviolet	far (abiotic)—vacuum	120–1850 A
	far (abiotic)—quartz	1850–3000 A
	near (biotic)	3000–3900 A
Visible	(to human eye)	3900–7800 A
Infrared	near	7800 A–20 μ
	far	20 μ–0.4 mm
Radio waves	experimental	0.1 mm to 1 meter
	radar	1 cm. to 1 meter
	transmission	1 to 30,000 meters

EFFECTS OF RADIO WAVES UPON CELL DIVISION

The apparently beneficial effects of radio waves on tumors and the use of radio-induced fever treatment of syphilis stimulated a great deal of interest in the effects of radio waves (Gosset et al., 1924; Schereschewsky, 1928; McKinley, chap. 15 in Dug-

gar, 1936; Schliephake, 1935). When an animal is exposed to radio waves, its temperature rises. A rise in temperature occurs not only in organisms but also in salt solutions exposed between the condenser plates, and certain concentrations of salts are optimal (Kahler, Chalkley, and Voigtlin, 1929; McClennan and Burton, 1930; Hoag, 1939). However, solid dry salt, sucrose solutions, benzene, and pure distilled water are not heated by radio waves, observations which show that the heating depends upon the presence of ions in aqueous solution. In addition to heating, these radiations might exert specific photochemical effects on organisms, and some workers believe that their data indicate such effects. Thus Grimaldi (1934), using eggs of a sea urchin, found an acceleration of cleavage which he interpreted as due to a specific wave effect but which could equally well be interpreted as due to heating alone. Jellinek (1936) claimed that the action of weak 3-meter waves on the movement and life of *Paramecium* and *Vorticella* is more rapid than can be accounted for by mere heating, but the experiments are not supported by convincing data. Haase and Schliephake (1931) have claimed that division of bacteria is more rapidly inhibited by exposure to a high frequency field than by heat at the same temperature. Thus 6 to 15 minutes at 55°C in the radio field is adequate to prevent division, whereas 30 minutes are required in the water bath.

The bulk of the evidence from a number of laboratories indicates that the effect of radio waves is due to the heating of the medium and the organism, and not to a photochemical effect. Thus Hasche and Leunig (1934) failed to substantiate the results of Haase and Schliephake. Using 8 and 20 meter waves, they found that bacteria do not die at sublethal temperatues. Kahler, Chalkley, and Voegtlin (1929) found no effects on paramecia of sublethal temperatures produced by 4 and 30 meter waves. Division of animals exposed to these waves was equal to that of the controls at the same temperature, although the detailed data are not included in the report. When heating of the medium was prevented by suspending the paramecia in sucrose solutions, no effect was obtained. When radio heating in balanced salt solutions proceeded to the lethal point, paramecia heated in a water bath to the same temperature died from a similar exposure. Whitney and Page (1935) and Breitweiser (1935), using bacteria, came to a similar conclusion, as did Gale (1935) with paramecia. Wenk (1939), finding that paramecia died at a temperature slightly greater than 42°C, kept the temperature slightly less than this critical point while irradiating with radio waves and found no evidence of specific photochemical injury. Summers and Hughes (1940), using wavelengths 5.2 and 23 meters, in a careful study found that the variations in rate of division of *Colpidium* in the radio field could be adequately explained as mere thermal effects. In these experiments the colpidia were kept in small capillary tubes, and a rise in temperature was prevented by water or air cooling. Bachem (1935) has pointed out that some discrepancies with microorganisms might result, at certain wavelengths, from local heating due to differences in ionic content of the organism compared with the medium. Thus yeast centrifuged from the medium heats more rapidly than the medium at some wavelengths, less rapidly at others. Bacteria heated less rapidly than the medium, but the difference varied with the wavelength. Growth of cultures of *B. prodigiosus* treated with radio waves in saline was found to be greater than cultures treated in distilled water, even though the temperature was kept the same in the two cases. However, the results were regarded by the author as preliminary and do not seem to have been followed up.

The general conclusion may be drawn that while there are some unexplained cases of apparent specific photochemical action of radio waves, the bulk of the evidence indicates that these waves affect cells merely by heating them. If the heat is sublethal, an increase in activity, including an increase in the rate of division, may occur; if it is carried to the lethal point, death will follow in the same way as from direct heating.

EFFECTS OF INFRARED RADIATIONS AND HEAT UPON CELL DIVISION

The effects of infrared radiations upon protozoa or other organisms can be readily observed with a microprojector from which the heat-absorbing cell is removed. First there is a rapid acceleration in swimming, and the animals attempt to escape from the field. If they fail, they die. If removed from the field before death, they recover and remain normal. Removed before they have become vesiculated, they divide. However, Nelson and Brooks (1933) found that irradiation of the eggs of the sea urchin and of the worm *Urechis* with infrared radiations of 0.8 and 1.2 μ impaired their fertilizability greatly, although their internal tem-

perature never rose more than 0.06°C above that of the controls. This is apparently the first clear evidence of a photochemical effect other than a heating effect and should be repeated on other forms. Several investigators have found evidence for other specific effects of infrared rays. Thus the number of chromatid breaks in infrared treated x-rayed *Tradescantia* chromosomes is greater than in those given x-ray treatment alone (Kaufmann, Hollaender, and Gay, 1946; Kaufmann, 1946; Swanson and Hollaender, 1946; see also reports by these investigators in the meetings of the Genetics Society, American Botanical Society, and the American Society of Zoologists, December, 1946). Since this topic is not closely related to the problem of cell division, it will not be further discussed here. However, it emphasizes the desirability of investigating the specific effects of infrared rays on cell division.

Most studies on the effects of heat are concerned with the determination of temperature coefficients. Studies on temperature coefficients are summarized in a number of books (Kanitz, 1915; Matisse, 1919; Przibram, 1923; Belehradek, 1935) and an interpretation of the temperature coefficient was attempted by Crozier (1924, 1926a, b) and criticized by Burton (1936) and Hoagland (1937). Biologists are prepared to admit that the increase in rate of division is due to the increase in rate of the chemical reactions, following increase in the numbers of molecules having a critical energy of activation. However, not many are willing to believe that specific master reactions can be identified in the complex series of reactions which occur in the cell. It is possible to differentiate readily between very different master reactions that have very different temperature coefficients, such as photochemical, ordinary chemical, and coagulation processes. The temperature coefficient of cell division is generally of the order of 2, and it falls with rise in temperature until division completely ceases and death ensues. Johnson and co-workers (1945) have interpreted this cessation of growth and division in luminous bacteria as being due to the reversible heat denaturation of growth-regulating enzymes, and have supported their views with an array of experimental data. What appears to be a readily reversible denaturation of similar enzymes was observed in *Paramecium* and *Blepharisma* (Giese, unpublished). It was found that growth and division of these forms would not continue at or above 35° C, yet when they were transferred to fresh culture medium at 26°C they divided at the same rate as the control. If they were exposed to sublethal doses at 42°C and then transferred to culture medium at 26°C, they multiplied at the same rate as controls even when the exposure lasted for more than one half the lethal dose. Therefore, if any denaturation of enzymes had occurred at the higher temperature, it must have been reversed.

The preceding thermal history may have an effect on division. Ryan (1941) found that the eggs of *Rana pipiens* will develop more rapidly than controls at a given temperature if they had previously been exposed to a lower temperature, and less rapidly than controls if previously exposed to a higher temperature. Acclimatization follows so that the rate approaches that characteristic for a given temperature. Unicellular organisms may slowly adapt to higher temperatures and multiply at temperatures previously inhibitory or even lethal (Dallinger, 1887; for other references see Belehradek, 1935, pp. 217–220). Such a change in resistance might be due to a change in the phospholipids of the organism (Heilbrunn, 1924; Belehradek, 1935; Heilbrunn, 1943, pp. 426–429) or to a change in the rate of denaturation of the essential proteins in the cell. The recent studies of Luck and his co-workers on the stabilization of serum albumin to high temperatures by addition of fatty acids may offer a clue. In these studies it was found that C_7 or C_8 fatty acids were especially effective and that an anion with a non-polar group was necessary for the protective action. It may be that lipids act in some similar way in bringing about stabilization. If denaturation is crudely conceived as being a mere opening up of a spherical protein, then the action of the stabilizers might be to tie up the side chains so as to maintain a corpuscular protein in the native state. In the denatured state the specific action is lost and if the protein is a part of an enzyme, the enzyme may cease to function (Ballou, Boyer, and Luck, 1945; Boyer, Ballou, and Luck, 1946; Boyer, Lum, Ballou, Luck, and Price, 1946; Neurath, Greenstein, Putnam, and Erikson, 1944).

Since some organisms are very sensitive to heat and others, such as the thermophilic forms, are relatively insensitive, it would appear that organisms have evolved to fit particular thermal environments. Thus marine organisms are generally accommodated to the low temperatures of the ocean and are more susceptible to heat than ter-

restrial and fresh water forms. Division of eggs of such animals is readily affected by relatively lower temperatures. The cause of their high susceptibility is not known. Perhaps the enzymes are less well protected than in more resistant organisms. Studies of enzyme extracts would be interesting.

The thermophilic organisms may represent the end result of a series of adaptations to high temperatures. In such organisms the enzymatic systems must withstand temperatures up to 73°C, since thermophilic algae grow in hot springs at this temperature and thermophilic bacteria grow at 60–70°C (Belehradek, 1935). Enzymes are known which can withstand these temperatures (Neurath, et al., 1944). Thermophilic organisms must differ from other organisms in possessing such enzyme systems or enzymes with stabilizers, perhaps of the type already described by Luck and his co-workers. It would be profitable to study the enzyme systems of such organisms in vitro. This would be particularly interesting if the heat-sensitive reaction could be identified. In a few cases the general thermosensitive reaction system has been identified. Mitchell and Houlahan (1946) have described a mutant of *Neurospora* which is able to make its own riboflavin at temperatures below 25° C, but above this temperature it must be supplied with riboflavin from the outside or it fails to grow. Another interesting mutant of *Neurospora* is one which requires sulfanilamide for growth at 36°C (S. Emerson, personal communication). This mutant is poisoned by p-aminobenzoic acid, reversing the usual antagonistic relationship between these compounds. Attempts have been made to extract and study the characteristics of the enzymes in the first case, but the results are incomplete (Mitchell and McElroy, personal communication).

No studies seem to have been made on the possible effect of heat exposure at different phases of the mitotic cycle. Such data would be interesting for comparison with the effects of visible, ultraviolet, and ionizing radiations. Similar studies searching for specific effects of infrared rays on mitosis are desirable. In such experiments heating should be prevented or kept to a very low value.

EFFECTS OF VISIBLE LIGHT UPON CELL DIVISION

Visible light seems to have no effect on colorless organisms such as *Paramecium*, the rate of division being the same in the light as in the dark. However, if a photodynamic dye such as eosin is added even in such low concentrations as 1:100,000 or 1:400,000, the division rate of animals continuously exposed to light is retarded. When the concentration is raised to 1:60,000 the paramecia do not divide and ultimately die, whereas in the dark the dye has no detectable effect on the division rate. In the presence of the dye the light, which is otherwise transmitted through the organism, is absorbed and so becomes effective in injuring the cell. On the other hand, colored organisms may be affected by light even in the absence of any dye in the medium, e.g., *Blepharisma* is retarded by exposure to even relatively weak light and is killed by exposure to intense light, whereas another red protozoan, *Holosticha*, is not (Giese, 1938, 1946a). Also the eggs of *Arbacia*, which contain an abundance of a red pigment, echinochrome, a naphthoquinone dye, resist about ten times the lethal exposure for *Blepharisma* without any noticeable effect in the division rate (Giese, unpublished). The nature of the pigment or the manner in which it is held in the cell may determine the action of light. Since *Blepharisma* represents a rather unique case, the nature of the pigment and its relation to the constituents of the cell are worthy of further study.

One would expect cell division in green plants to depend upon light, since the plant makes its own food by photosynthesis. On this assumption red light, which is most effective for photosynthesis, should be most stimulating to growth; but no systematic study of these relations seems to have been made. It would also be of interest to know what effects visible light has upon growth and nuclear division in the hyphae of fungi.

The effect of visible light on mitosis in the presence of photodynamic dyes has been explored by a number of investigators. Tennent (1938; 1942) described cytological defects following such treatment of eggs of various marine animals, exposed in the presence of various photodynamic dyes. Patterson (1941) illuminated barley root tips in neutral red solution for an hour, then kept the plants in the dark, and studied the number of cells in division following treatment. First, cells entering division declined in number. Then cells which had been in interphase during exposure divided, after which no cells entered division. Lewis (1945) studied the effect of light on dividing cells of the chick in tissue culture containing fluorescent substances such as chlorophyll, methylcholanthrene,

and eosin. No effect was observed in the dark, but dividing cells exposed to light became abnormal, while resting cells were unaffected. Cells in prophase were readily stopped; cells in anaphase sometimes completed division. Illuminated resting cells later underwent division after being placed in the dark. Frankston (1940) illuminated the integument of *Triturus* in neutral red solutions and found that when the dividing cells are checked in metaphase they later complete the division apparently normally, but if they are checked in prophase various abnormalities appear. No extended study of the effects of the light at different phases in mitosis seems to have been made. Such a study would be interesting for comparison with x-ray and ultraviolet effects.

EFFECTS OF ULTRAVIOLET LIGHT UPON CELL DIVISION

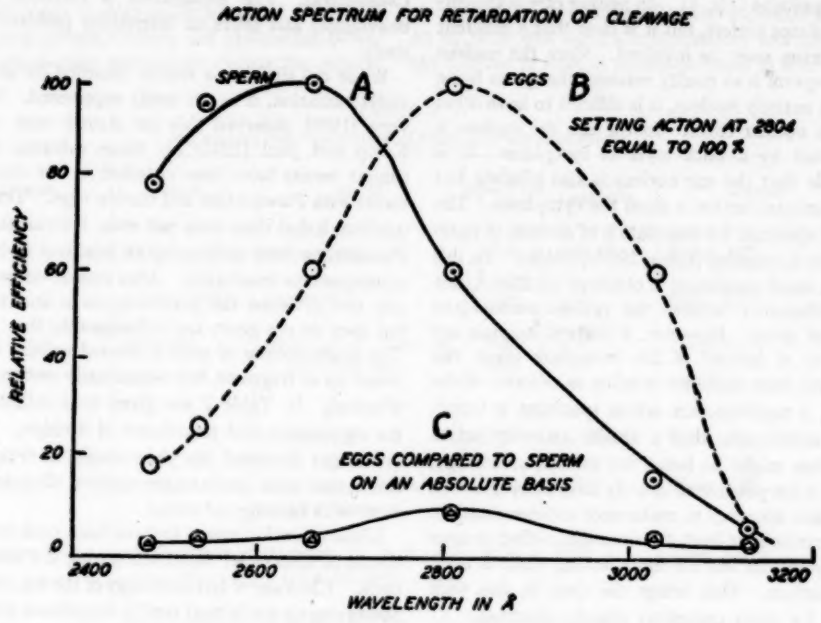
Suppression of division was one of the earliest discoveries of the effects of ultraviolet light upon cells (Downes and Blunt, 1877). The action spectrum for suppression of division of bacteria was determined by Sonne (1929) and Gates (1929, 1930) and has been corroborated by many other workers since that time (Duggar, ch. 36, 1936). An action spectrum compares the relative efficiency of various wavelengths in producing a given effect. The method and various action spectra have been described in detail in a previous paper (Giese, 1945a). The action spectrum is thought to have significance, in that it is probably a measure of the absorption of the radiations by some compound in the cell responsible for the reaction to the radiation. Determination of the action spectrum is therefore a possible means of identifying the active constituent in the cell. The action spectrum determined by Gates resembles the absorption by nucleoproteins. It might therefore be tentatively concluded that the action of ultraviolet radiations is by virtue of injurious effects on the nucleoproteins of the bacterial cell. It is noteworthy that the most effective radiations lie in the region below 3000 Å, i.e., 3000–2000 Å. or shorter. Wavelengths of 3000–4000 Å. have much less effect on growth and division of cells (see Giese, 1945a, Table 2, for a summary of the literature).

Gates (1933) showed that the growth processes of the organism are probably less sensitive to ultraviolet light than cell division, since after division ceases bacteria still continue to grow at a reduced rate. As a consequence they form long spaghetti-like filaments of clear, highly refractile protoplasm, filaments which may reach dimensions of 50–150 μ and even a transverse diameter of three times the normal diameter. In two to four hours at 37.5°C after treatment, such cells reach a limit and either divide or degenerate. Sublethal effects of ultraviolet light have also been studied by Hollaender and Duggar (1938) and by Hollaender (1945).

The earlier studies on animal cells were mainly studies on the death and disruption of such cells (Dreyer, 1903, 1904). However, in 1909 Stevens and in 1923 Schliep studied the effects of short wavelength ultraviolet radiations upon *Ascaris* eggs. Following irradiation, various chromosomal abnormalities appeared in the cleaving eggs, such as clumping, excessive chromatin elimination, thickening of the chromosomes and thickening of the nuclear membrane, lagging of some of the chromosomes during division, and unequal division of the chromosomes. Schliep demonstrated that the same abnormalities could be obtained by irradiating either the nucleus or the cytoplasm of the egg with a pencil of rays of 2800 Å, but the dosage required in the latter case is many times the former, indicating a much greater sensitivity of the nucleus. In these experiments Schliep also irradiated the centrosome but showed that this treatment had no greater effect on the abnormalities produced than irradiation of the cytoplasm. The different zones in centrifuged cells were found to be equally sensitive. These experiments are interesting in that they suggest the great sensitivity of the nucleus to the action of the radiations in disrupting the normal mitotic divisions.

An attempt to determine the ultraviolet action spectrum of inhibition of growth was made by Mayer (1934) and Mayer and Schreiber (1934). They determined the growth in area of tissue cultures of mesenchyme after irradiation with various wavelengths of monochromatic ultraviolet light. While the range in values obtained is very large, the results suggest the nucleoprotein absorption curve.

The action spectrum for retardation of division of cells has been determined in a number of cases. When eggs of the sea urchin are irradiated, the action spectrum obtained resembles the absorption spectrum for simple cytoplasmic proteins more than it does that of nucleoproteins. If, on the other hand, the spermatozoa are irradiated and used to fertilize unirradiated eggs, the retardation of division corresponds more to the absorption by



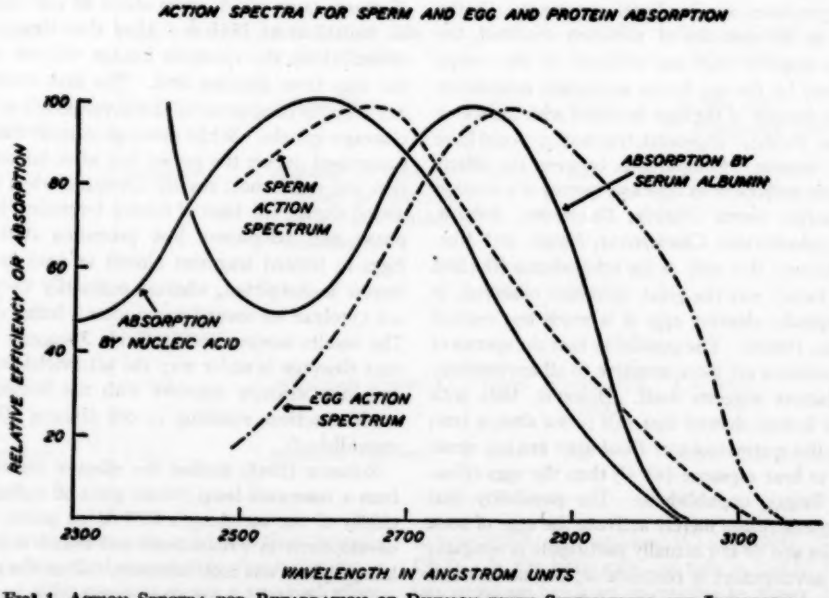


FIG. 1. ACTION SPECTRA FOR RETARDATION OF DIVISION WHEN SPERMATOZOA ARE IRRADIATED AND WHEN EGGS ARE IRRADIATED
(From Giese, 1946b)

nucleoproteins (Fig. 1). In neither case is the correspondence perfect, but it is clear that a different mechanism must be involved. Since the nucleus of the sperm is so readily reached, the sperm being almost entirely nucleus, it is difficult to have other than a nuclear effect. In the egg the nucleus is protected by a thick layer of cytoplasm It is possible that the egg nucleus is also affected, but the dominant action is upon the cytoplasm. The action spectrum for retardation of division of paramecium is puzzling (Giese, 1939a; 1945b). In this case a small maximum is obtained at 2800 Å, but the differences between the various wavelengths are not great. However, if starved animals are used or if, instead of the immediate effect, the recovery from radiation is taken as criterion of the effect, a nucleoprotein action spectrum is found. It is conceivable that a similar recovery action spectrum might be found for the sea urchin egg, but it is not possible to identify later cleavages with sufficient accuracy to make such a determination. In paramecia, at least, the immediate effect is upon the cytoplasm but the more lasting effect is upon the nucleus. This brings the data in line with those for other organisms already described.

The great difference in sensitivity of sperm and egg, suggesting a like difference between nucleus and cytoplasm, requires further comment. On the basis of the quantity of radiation absorbed, the sperm requires only one millionth of the energy required by the egg for an equivalent retardation in the division of the eggs fertilized with the sperm (Giese, 1939b). If general, this finding would have great interest. Comparisons between the effects of these radiations on eggs and sperms of a number of marine forms (*Patiria*, *Dendraster*, *Arbacia*, *Strongylocentrotus*, *Chaetopterus*, *Nereis*, and *Mactra*) showed that only in the echinoderms (the first four listed) was the great difference observed; in the spirally cleaving eggs it is much less marked (Giese, 1946b). The possibility that the sperms of echinoderms are more sensitive to all environmental factors suggests itself. However, tests with other factors showed that this is not always true; thus the spermatozoa of *Dendraster* are less sensitive to heat exposure (42° C) than the eggs (Giese and Briggs, unpublished). The possibility that the spermatozoa merely activate the eggs of some species and do not actually participate in syngamy and development is conceivable, but no evidence for exclusion of the sperm and fragmentation and degeneration of its chromosomes was obtained in *Chaetopterus*. The explanation is therefore still unavailable and offers an interesting problem for study.

While cell division is readily retarded by ultraviolet radiation, it is not easily suppressed. Stevens (1909) observed this for *Ascaris* eggs and Kemp and Juul (1932) for tissue cultures, and similar results have been obtained in our experiments with *Paramecium* and marine eggs. Thus a minimal lethal dose does not stop individuals of *Paramecium* from undergoing at least one division subsequent to irradiation. After one or occasionally two divisions the paramecia swim and feed, but they do not grow, and subsequently they die. The macronucleus of such a treated animal may round up or fragment, but occasionally recovery is obtained. In Table 2 are given data exhibiting the suppression and retardation of division. Lea (1947) has discussed this phenomenon in detail in connection with similar observations after treatment with ionizing rad ations.

Little attention seems to have been paid to the effects of ultraviolet radiations during the mitotic cycle. Cleavage of fertilized eggs of the sea urchin *Strongylocentrotus* is most readily suppressed during the first 45 minutes after insemination by treatment with the radiations from a mercury argon discharge lamp which emits about 85 per cent of its radiations at 2537 Å. After that time even several times the cytolytic dosage will not stop the eggs from dividing first. The first seventy-five minutes correspond to the development of the cleavage spindle. While cleavage is most readily suppressed during the period just after insemination, the egg is most readily cytolyzed when irradiated during the time of furrow formation (anaphase and telophase) just preceding division. Eggs so treated fragment almost as soon as the furrow is completed, whereas ordinarily they do not cytolyze for several hours after a lethal dose. The results summarized in Table 3 suggest that once cleavage is under way the ultraviolet injury does not seriously interfere with the immediate set of reactions resulting in cell division (Giese, unpublished).

Swanson (1943) studied the effect of radiations from a resonance lamp (which gives off radiations chiefly of the wavelength 2537 Å) on pollen tube development in *Tradescantia* and found that the late prophase was most sensitive. Thus the sensitivity at 0 and 1 hour after germination was less than at 2 hours and declined until at 11 hours after

germination it fell to a minimum. In the most complete study to date on the effects of ultraviolet light upon mitosis Carlson and Hollaender (1944) rayed grasshopper neuroblasts during the mitotic given in 1, 15, or 1500 seconds, as is to be expected on the basis of the Bunsen Roscoe reciprocity law. At no time was there a compensatory increase in the number of cells in mitosis, a result in contrast

TABLE 2

Retardation and suppression of division by ultraviolet light

ORGANISM	STAGE	RESULT	WAVE-LENGTH (in Å units)	DOSAGE (in ergs/mm²)	CITATION
Bacteria (*S. aureus*)	active culture	suppression	2654	80–90	Gates, 1929
Yeast	active culture	suppression	2654	450	Oster, 1934
Sea urchin egg	prophase	doubling of time of third cleavage	2654 2804	3100 1400	Giese, 1938a
		suppression	2537	ca. 25,000	Giese, unpublished
Urechis egg	prophase	doubling of time of third cleavage	2654	2200	Giese, 1939c.
Paramecium	active culture	doubling of time of third division	2654	1800	Giese, 1939a
	starved culture	doubling of time of third division	2654	250–400	Giese, 1945b.
Blepharisma	active culture	doubling of time of third division	2654	ca. 1,600	Giese and Reed, unpublished
Grasshopper neuroblast	prophase	definite delay	2537	60	Carlson and Hollaender, 1944
	prophase	doubling of time required to complete early and middle prophase	2537	360	
	very late prophase to ana-anaphase	no effect	2537	360	
Tissue culture	active	retardation of growth	mixed	1/10–1/15 lethal	Kler, 1925
Tissue culture	active	inhibition of growth	2654	500	Meyer and Schreiber, 1934

cycle of some of the cells and found that the early prophase was most retarded by the radiations, a dosage of 6000 ergs/cm² giving a maximal effect. The effect was the same whether the dosage was

to x-ray effects on neuroblasts (Carlson, 1940, 1941, 1942). In the latter case the cells in middle and late prophase are most susceptible to x-rays, and treatment cuts off the supply for midmitotic ac-

tivity abruptly and completely. Cells from earlier stages slow up on reaching middle and late prophase. Then, as recovery sets in, the accumulated cells progress almost simultaneously, so that the number of cells in mitosis in irradiated cultures may be greater than in controls. Since this does not happen in ultraviolet-treated cultures, Carlson and Hollaender consider recovery from such injury to be very slow. This is in keeping with studies on recovery from ultraviolet injury of sea urchin eggs and paramecia. Thus eggs irradiated with a dosage sufficient to give readily measurable retardation, and then inseminated immediately, 1, 2, 4, and 6 hours after irradiation show approximately the same degree of retardation (Giese, unpublished). In studies on paramecia it was demonstrated that many cell generations must occur before the rate of division approaches the rate existing before irradiation. The paramecia must be fed or recovery will not occur (Giese and Reed, 1940). The necessity of metabolic activity for recovery shows up most strikingly in the recovery from heat sensitization studied with paramecia (Giese and Crossman, 1945). It would appear that for recovery to occur the modified or denatured molecules must be replaced during the activities of metabolism. In no case was acceleration of the division observed after irradiation, a result indicating that in these cases as well the consequences differ from the effects of x-rays.

Carlson and Hollaender (1945) also studied the effect of intensity upon cell division. Using a dosage which reduces the number of mitoses to less than one-third of normal, high intensity was found to be more effective than low. This was not observed for lower dosages.

Caspersson (1936, 1940a, b, 1941), Caspersson and Theorell (1941), and Caspersson, Landstrom-Hyden, and Aquilonius (1941) have studied the relation between nucleic acids and the chromosome cycle with considerable success. It is out of place to review and evaluate all of this work here, since much of these data deals with other problems. However, a very brief summary will help to interpret some of the ultraviolet effects being discussed.

TABLE 3

Stage in development reached after irradiation of fertilized eggs of the sea urchin Strongylocentrotus purpuratus with ultraviolet light from a discharge tube (mainly λ 2537 Å)

DEVELOPMENT OBSERVED AT TIME OF IRRADIATION	MIN. AFTER INSEMINATION	DOSAGES IN SECONDS (intensity estimated at about 500 ergs/mm²/sec.)			
		45	60	90	120
		Stage in development reached (number of cells)			
Sperm entrance (prophases)	1–30	1 (4)	1 (4)		
	31–45		1 (4)		
	46–60		2 (4)	2 (4)	1 (2)
	61–75		2 (4)	2 (4)	1 (2)
Nuclear spindles appear (metaphase)	76–90		2 (4)	2 (4)	1, 2
Furrows show (anaphase and telophase)	91–105		2 (4) cyt.	2 (4) cyt.	2 cytolyze
All cleave (most 110)	106–120		2–4	2–4	2–4

Note: Figures in parentheses indicate stage reached by a small proportion of the cells.

Ultraviolet absorption measurements of sections of tissue enable one to determine the total amount of nucleic acid present, since both ribose and desoxyribose nucleic acids absorb these radiations equally well, the absorption being determined by the nitrogenous constituents present. However, the Feulgen reaction appears to be confined to desoxyribose nucleic acid. Although staining reactions are difficult to use quantitatively, they can be used to indicate the order of magnitude of a reaction. By using the two techniques together it is possible to estimate the quantities of the two types of nucleic acid present. The nucleic acid which appears in the cytoplasm and in the nucleolus is negative to Feulgen and is thought to be of

the ribose type. Desoxyribose nucleic acids are found only in the chromosomes, and even in the chromosomes there is a periodic interconversion between the ribose and desoxyribose nucleic acids. Caspersson and his co-workers have shown that the desoxyribose nucleic acid increases gradually during the prophase and reaches a maximum concentration during the metaphase but falls during the anaphase and reaches a minimum during the interphase. Nucleic acid accumulates in the chromosomes, and it is thought that the nucleoprotein formed by the union of proteins and the desoxyribosenucleic acid is the seat of the active genes in the euchromatin (Caspersson and Schultz, 1940; Schultz, Caspersson, and Aquilonius, 1940). As the desoxyribosenucleic acid in the chromosomes declines the ribonucleic acid increases. The nucleolus appears to originate in the heterochromatin and is thought to be a center of activity in the production of ribonucleic acid.

Parallel with the nucleic acid cycle in the nucleus is a protein cycle. In prophase the complex proteins of the nucleus begin to decrease in amount and the histones begin to appear, reaching a maximum at metaphase. Here again spectroscopic methods can be employed, since histones possess fewer aromatic amino acids than the complex proteins and show a less characteristic protein absorption. At telophase the histones in the euchromatic proteins of the chromosomes begin to disappear as complex protein is reformed, but in the heterochromatic portions histones are present through the interphase (see Greenstein, 1944, pp. 274–281 for a summary of the literature and references).

In view of the nucleic acid cycle it is interesting to find the early prophase to be the stage of division most sensitive to radiations (Carlson and Hollaender, 1944). Since desoxyribose nucleic acid is present in largest amount during the metaphase, one might expect greater effects at that time. However, during the prophase the chromosomes, being elongate, present a greater area for absorption of the radiations. It is also possible that the attachment of nucleic acid to the protein skeleton of the chromosome leads to the stabilization of the latter and acts as a protective sheath, as suggested by Swanson (1943). In this regard it would be interesting to know what correlation exists between mitotic or meiotic phases of development and the rate of mutation induced. This should yield some interesting information regarding the nature of the change underlying mutation. Apparently no such data are yet available. It is interesting to find, however, that in general the rate of mutation is roughly correlated with the absorption by the nucleic acid component of the nucleus (Hollaender and Emmons, 1941; Hollaender, Sansome, Zimmer, and Demerec, 1945; Stadler and Uber, 1942; Schultz, Caspersson, and Aquilonius, 1940). Hollaender and Emmons (1941) have suggested that the mutation effect is upon the euchromatin, whereas the retardation of cell division is an effect upon the heterochromatin.

The possibility of an acceleration of biological processes by ultraviolet radiations has long been claimed. According to the mitogenetic school, all cells emit short ultraviolet radiations which stimulate other cells to more rapid division (Frank and Gurwitsch, 1927; Gurwitsch, 1934; Rahn, 1936). Other workers have found no physical or biological evidence for the mitogenetic radiations (Hollaender and Shreffel, 1931; Lorenz, 1934; Bateman, 1935; Duggar, 1936, ch. 28), and at present there is no indisputable proof of their existence. However, with use of ultraviolet sources an acceleration of cell division has been claimed. Thus Alpatov and Nastiukova (1932, 1933, 1934) stated that mixed radiations from a quartz mercury arc cause an 8 to 10 per cent increase in division of paramecia, in 90 per cent of the cases. Hinrichs (1928) believed that *Paramecium* and MacDougall (1929, 1941) that *Chilodon* cultures develop more vigorously after exposure to radiation of a quartz mercury arc. Hutchinson and Ashton (1939), using monochromatic light of unknown intensity, claimed that the short radiations were injurious but that long radiations were stimulating to infusions of paramecia. Chase (1937, 1938) in careful experiments found that sand dollar eggs might show a slight acceleration in rate of division after irradiation. Data on reports of stimulation are summarized in Table 4.

Buschke, Friedenwald, and Moses (1945) found that cells in the rat cornea can be stimulated to divide by small doses of the mixed radiations from a quartz mercury arc. After larger dosages, a decrease in division, followed by an acceleration, was observed. With very large doses, a retardation coupled with degenerative changes was observed.

The most striking results showing an acceleration of the division rate of cells are those reported by Meier (1939) and Meier-Chase (1941), who found that the alga *Stichococcus bacillaris* divided

much more rapidly, following raying with about ¾ the lethal dosage. This stimulation has persisted for several years, and the cells are shorter and wider than those of the original cultures. It is likely that the effect of the radiations was upon the hereditary characters of the algal strain. Recently a cell-free filtrate of irradiated cells was found to stimulate growth more than a similar filtrate from controls (Giersch, 1945). Further analysis of this interesting work is desirable.

Stimulation of the division of cells has also been claimed by Sperti and his co-workers. In these experiments yeast or other cells are slowly injured and killed by ultraviolet light of mixed wavelengths (Sperti, Loofbourow, and Lane, 1937; Sperti, Loofbourow, and Dwyer, 1937; Loofbourow, Dwyer, and Morgan, 1938), and various materials which diffuse out from the injured cells stimulate other cells to divide. These materials are not merely released but rather are synthesized by the

TABLE 4

Reported acceleration of division of cells following ultraviolet irradiation

ORGANISM	RESULT	λ (IN Å)	DOSAGE	CITATION	REMARKS
Bacteria (*E. coli*; *S. marcescens*)	30–40% increase before lag sets in	2650	95% killed	Hollaender & Duggar, 1938	see 2 as possibility
Yeast	increased rate of budding	mixed	very low int.; sublethal.	Sperti et al., 1937; Loofbourow et al., 1938–47	Effect of growth factors, etc., liberated
Stichococcus bacillaris (alga)	4.7 × increase 3.9 × increase 4.6 × increase 1.6 × increase	2532 2483 2652 2967	¾ lethal	Meier, 1939; Meier-Chase, 1940	probably genetic effect
Paramecium	retarded, then slightly increased rate	2800	1/10 lethal	Bovie & Hughes, 1918	significance questionable
Paramecium	8–10% increase	mixed	not meas.	Alpatov and Nastiukova, 1932, 1933, 1934	significance questionable
Paramecium	"better" cultures	mixed	not meas.	Hinrichs, 1928	inadequate concontrol of cultures
Paramecium	Stimulation	monochromatic long or near u.v.	not meas.	Hutchinson & Ashton, 1929	inadequate control of cultures for determination
	retardation	monochromatic far or short u.v.			
Chilodon	"better" culture	mixed	not meas.	MacDougall, 1929; 1931	inadequate control of cultures
Sand dollar eggs	accel. if rayed just before cleavage	mixed	not meas. (low)	Chase, 1937, 1938	
Rat cornea	increase in mitotic figures	mixed	not meas.	Buschke, Friedenwald, & Moses, 1945	

cells as they die, since cells killed quickly do not produce them. Photomicrographs show an increased production of ultraviolet absorbing materials (Loofbourow and Joyce, 1941). Most effective production occurs when adequate oxygen is present and a suitable substrate is supplied. Agents other than ultraviolet light are observed to produce similar effects, e.g., bubbling CO_2, lack of oxygen, x-rays, chemical injury, and mechanical injury (Loofbourow and Dwyer, 1939).

A mixture of substances has been identified in the cell-free intercellular material of ultraviolet-treated cultures: members of the vitamin B complex (Loofbourow, Cook, and Stimson, 1938; Loofbourow, Dwyer, and Cronin, 1941; Loofbourow, Dwyer, and Lane, 1940; Loofbourow, Webb, and Abramovitz, 1942; Webb and Loofbourow, 1947), amino acids (Loofbourow, 1947) and nucleotides and nucleosides (Loofbourow, Englert, and Dwyer, 1941; Loofbourow, Oppenheim-Errera, Loofbourow, and Yeats, 1947). Mixtures of such substances have the same growth-promoting activity as the cell free filtrates.

Not only cleavage delay but chromosome changes and interference with normal division by ultraviolet light have been claimed by a number of workers. Thus MacDougall (1929, 1931) found triploids and tetraploids in irradiated cultures of *Chilodon*, some of which bred true. Abnormalities, including giants, were obtained but did not persist. Hinrichs (1928) also found abnormalities in *Paramecium*, particularly chains of individuals and monsters. In our studies with *Paramecium* of three species, running over a period of seven years, and with *Blepharisma* and *Stylonchia* for a shorter time, in all cases under controlled conditions of temperatures, pH, bacterial food, etc., no chains or monsters were observed as a result of ultraviolet radiations of a wide range of intensity and wavelength. It is doubtful whether the abnormalities observed by Hinrichs were really produced by ultraviolet light. In our studies we obtained monsters in a few cases when conditions were not quite normal, but they appeared in both control and irradiated cultures. Giants could be produced by abnormal feeding, including cannibalism (DeGaris, 1927; Giese and Alden, 1938; Giese, 1938b), and these giants sometimes give rise to monsters (Giese, 1938b).

Ultraviolet light causes development of cancer if the animal is exposed for long periods of time (Blum, 1943). The stimulation of division which occurs in irradiated tumors probably results from death of certain cells and the general disorganization of the remaining tissue. However, the mechanism of action in this case has not been worked out. Another complex problem still awaiting solution is the mechanism of action of these radiations in curing skin diseases such as lupus vulgaris, but whether this involves effects on cell division is unknown, since the data available are still inadequate (Mayer, 1932; Ellinger, 1941).

Ultraviolet light affects protoplasm probably by activation of the protein molecules, and the action spectra show which type of proteins are involved in this biological effect. A detailed discussion of the chemical action of the radiations is outside the scope of this review, but a few pertinent papers may be mentioned. Some information is available on the changes produced in nucleoproteins by ultraviolet light. Greenstein and Jenrette (1941) and Hollaender, Greenstein, and Jenrette (1941–42) have demonstrated that nucleic acid is depolymerized by ultraviolet radiation and assumes a less asymmetric form, as judged by the decrease in its structural viscosity. Irradiated nucleoprotein also loses the capacity to form fibers when added from salt solutions to distilled water (Giese, unpublished). Entire nucleoproteins were extracted from the sperm of a sea urchin (*Strongylocentrotus purpuratus*) by the method of Mirsky and Pollister (1942). These nucleoproteins form structural fibers of small diameter but 2 to 10 centimeters long, when added to distilled water from 2M NaCl. After irradiation of the nucleoprotein in salt solution with ultraviolet light, smaller fibers were produced upon adding the solution to distilled water, and after four hours with a dosage of 215 ergs/mm.^{2}/sec. for a layer 2 mm. thick the fibers failed to form. A murky solution appeared upon adding the nucleoprotein in salt solution to distilled water. Perhaps depolymerization underlies this change in properties. The clumping and abnormal behavior of the chromosomes of cells observed by Schleip (1923) and others may perhaps occur as a result of changes in the surface properties of the chromosomes, with resulting stickiness, as suggested by Darlington (1942) for ionizing radiations.

Proteins such as the albumins are denatured by ultraviolet light (Bovie, 1913; see also Clark, 1935). Denaturation involves the loss of specific properties, decreased solubility, etc., and results in the opening up of the molecule, exposing hydrophobic groups and reactive groups such as the sulfhydryl (Mirsky and Anson, 1935). But it is likely that in addition to denaturation the molecule is actually

fragmented by photolysis (Mirsky and Pauling, 1936; Svedberg and Brohult, 1939; Carpenter, 1940, 1941). Carpenter has shown that synthetic peptide bonds are broken and that the energy can travel from the absorbing group over several carbons in the chain to the peptide bond. He has also shown that synthetic peptides containing a chromophore such as the phenol of tyrosin are photolysed. Films of insulin are fragmented by ultraviolet radiations, and a phenolic compound, presumably tyrosine, appears in the solution. Evidences of fragmentation have been obtained by numerous workers who used proteins in their studies. The fragmentation may be followed by aggregation, so that electrophoretic patterns of proteins irradiated for long periods of time show mainly one large peak (Davis, Hollaender, and Greenstein, 1942). Prolonged irradiation may also involve, first, an increase in absorption, indicating new chemical combinations, and second, a loss of specific absorption, indicating a destruction of aromatic absorbing configurations (Arnow, 1936).

Photolysis may underlie chromosome fragmentation, weakening the binding and so allowing for a split when the chromosome is placed under a stress. Ultraviolet light does not break two chromatids at the same time at the same place, as ionizing radiations do (Lea, 1947).

From results on the heat sensitization of cells, it would appear that either proteins can be partially disrupted by ultraviolet radiations or that the photolysed proteins may still function as long as thermal agitation is not so great as to tear them apart. Thus paramecia, given small doses of ultraviolet light which in themselves do not change the rate of division (a sensitive indicator of ultraviolet action), are killed by heat which does not kill the controls (see, e.g., results at 2483 Å, Giese and Crossman, 1945). Heat applied before the radiation has no effect. Ultraviolet light lowers the temperature threshold for flocculation of proteins, as shown by Clark (1935), so that at any temperature above 4°C flocculation will occur, the reaction being more rapid the higher the temperature. The amount of flocculation depends upon the dose of radiation. Unirradiated protein shows no appreciable flocculation below 40°C. A somewhat similar sensitization of nucleoproteins has been observed. Thus boiled nucleoprotein in salt solution will not develop fibers upon addition to distilled water and merely forms a murky solution. However, nucleoprotein can be kept at 80°C for an hour without losing this property, the fibers being formed as well as in the control and the water in which they form remaining clear. Ninety minutes irradiation, under the conditions mentioned above, does not destroy the property of forming fibers, although perhaps the fibers are not as long as in controls. However, a solution so exposed to light and then placed in a water bath at 80°C for ten minutes loses its capacity for forming fibers, and only a murky solution is obtained (Giese, unpublished). The latent effect of the radiation has been developed by heat.

The question arises as to whether ultraviolet light, like ionizing radiations, produces in water hydrogen peroxide or hydrogen radicals which might then affect the proteins indirectly. While the energy of ultraviolet quanta is adequate to produce a photodecomposition of water, the absorption of these radiations by water begins at a wave length of about 2000 Å, and around 1800 Å a continuum sets in, with maxima at 1760 and 1360 Å. At these wavelengths one might expect peroxide to be formed, and it is produced in water vapor, but Fricke (1935) was unable to find it in liquid water even in the presence of oxygen. He also questioned the claim that hydrogen peroxide is formed by quartz ultraviolet radiations (2000–3000 Å). In fact, hydrogen peroxide absorbs radiations shorter than 3000 Å and is decomposed thereby (P. A. Leighton, personal communication). Ozone is produced by short ultraviolet light, the 1849 Å line in the mercury arc spectrum being potent in this respect. When a monochromator is used this can be disregarded as a factor. If the entire spectrum is used, it is necessary to ventilate and to prevent bubbles of air in the solutions being irradiated.

EFFECTS OF IONIZING RADIATIONS ON CELL DIVISION

The inhibition of the division of cells by x-rays was first observed by Bohn and Perthes and has been corroborated by many investigators, who used a wide variety of plants, animals, and bacteria (Packard, 1931). Bergonie and Tribondeau (1904, 1906) found that cells are affected by short radiations in proportion to their degree of activity and of undifferentiation. This was an important finding for cancer therapy, since malignant cells are more actively engaged in division than normal cells and are therefore more susceptible to radiations. It is impossible to give the historical development of this subject or to cover its voluminous literature,

and for this purpose the reader is referred to other publications, e.g., Warren, 1928; Glasser, 1933; Johnson, 1936; Failla, 1939, 1940; Packard, 1931, 1945; Glasser, Quimby, Taylor, and Weatherwax, 1945; Gray, 1945; Spear, 1946; and Lea, 1947. Lea's critical study is a discussion of the mechanisms of action of ionizing radiations and also includes excellent chapters on the nature of radiations and their chemical effects. For recent reports on some of the effects of the atomic bomb, the papers of denHoed (1946), Larkin (1946), Stone (1946), Timmes (1946), and Dobson and Lawrence (in press) may be consulted.

The effect of x-rays or other ionizing radiations on cells depends upon the dosage as well as upon the material irradiated. Thus large doses completely and permanently stop division. Smaller doses have temporary effects from which recovery appears to be complete. The nature of the action of radiations is somewhat different on tissue cultures and on protozoa. Thus, if tissue cultures are x-rayed with less than the dosage required to prevent division, the cells actually undergoing mitosis complete division, whereas cells in incipient stages of mitosis become quiescent (Strangeways and Hopwood, 1926). Recovery from small doses is fairly rapid, and the number of cells which later undergo mitoses at the same time will be greater than in the control. This happens because, in addition to the normal crop of mitoses, the cells which have recovered from radiation injury also divide. In such a case the average number of mitoses may be unchanged (Canti and co-workers, 1926, 1928, 1929, 1930; Moppett, 1932). However, in contrast to these results, small dosages of x-rays are said to stimulate paramecia to a more rapid rate of division for a short time, after which a depressed rate is observed (Hance and Clark, 1925). A similar course of events is described for mitoses in *Vicia faba* by Jungling and Langendorff (1930). Packard (1916) also reports acceleration with *Arbacia*. Intermediate dosages produce a lag in *Paramecium*; division may not occur for several days, but once it starts the rate is similar to that in the controls. Only when very large dosages are given is the rate of division altered as well (Giese and Heath, unpublished). Back and Halberstaedter (1945) report even longer lag periods than those we observed. Some organisms withstand radiations until they divide, whereupon they disrupt (Halberstaedter and Back, 1942).

The radiosensitivity of cells depends not only upon the species and the prevailing activity, but also on the conditions of the environment to which the cells are exposed at the time of raying and to some extent on the conditions after raying as well. Thus, reduction of oxygen or addition of cyanide increases the radiosensitivity of cancer cells and bean seeds to radium (Crabtree and Cramer, 1933; Scott, 1937; Packard, 1945). Inhibition of glycolysis by iodoacetic acid apparently has no effect; but acidification of the protoplasm increases and alkalinization decreases radiosensitivity, as shown by the effects of ammonia, carbon dioxide, and hydrogen sulphide in the experiments of Sizova (1936), Zirkle (1936, 1940, 1941) and Marshak (1938). Chilling increases radioresistance (Scott, 1937; Evans and Kerr, 1943; Latarjet, 1943; Goodrich, 1943). Lethal action of the radiations is also potentiated by ether, chloroform, ethyl ether and pentane, but not by nitrous oxide. Wilbur and Recknegel (1943) found that changes in the salt content of the water had marked effects on the radiosensitivity of *Nereis* eggs. Thus treating the eggs with .35M potassium citrate inhibited the retarding effects of the x-rays on cleavage unless the dosage was very great. The radiosensitivity of the eggs was not altered by increasing the calcium and magnesium of sea water. The degree of hydration also has a strong effect on the susceptibility of tissues to x-rays; thus seeds which have been soaked in water are less resistant than when dry (Packard, 1931, 1945). This may be due to the activity initiated by hydration. Packard (1930) indicated that not merely the conditions before and during irradiation but the conditions after irradiation as well are important in determining the effects on the biological material. Thus when temperature was varied, the radiosensitivity of *Drosophila* eggs was found to increase less than the increase of the number of cells in division stimulated by the rise in temperature. Any theory of the action of the radiations should be able to account for all these variations in responses to the radiations.

While the sensitivity of the dividing cell is recognized, there is no general agreement as to which stage of mitosis or meiosis is most sensitive. Practically every stage of the cycle has been regarded as the most sensitive phase. The data are briefly summarized in Table 5 (see also chapter 8 in Lea, 1947). As can be seen from the data in the table, the criteria which have been used for judging sensitivity are quite varied, and one might expect that different conclusions would be reached. More disturbing is the fact that even with the same criterion

TABLE 5

Stage of mitosis most sensitive to ionising radiations

ORGANISM	RADIATION	MOST SENSITIVE PHASE	CRITERION	CITATION
Sea urchin egg (*Arbacia*)	radium	prophase	retardation of cell division	Packard, 1916
Sea urchin egg (*Arbacia*)	x-rays 7800 + r	prophase	same	Henshaw, 1938a, b, 1940; Henshaw and Cohen, 1940
Grasshopper neuroblast	x-rays	middle and late prophase	delay in passing through late prophase	Carlson, 1940, 1942
Ascaris egg	x-rays	metaphase and anaphase	suppression of mitosis	Holthusen, 1921
Chick tissue culture	x-rays	prophase	same	Strangeways and Hopwood, 1926
Frog egg (*Rana fusca*)	x-rays 70–210 r	anaphase and telophase	death by third division	Vintemberger, 1928
Frog egg (*Rana fusca*)	radium	increasing from late prophase to telophase	death by gastrula stage	Luther, 1938
Sea urchin egg (*Psammechinus*)	x-rays 200 r	prophase and telophase most sens., metaphase least	fraction injured	Langendorff and Langendorff, 1931
Wasp egg (*Habrobracon*)	x-rays 2500 r	metaphase	mortality in development	Whiting, 1939, 1940
Plant buds (*Gasteria*)	x-rays	meiotic prophase	frequency of induced chromosome aberrations	Marshak, 1935
Plant microspores (*Tradescantia*)	x-rays 150–200 r	prophase; decrease toward metaphase	frequency of induced chromosome aberrations	Sax, 1940; Sax and Swanson, 1941
Plants: *Tradescantia*, tulip, hyacinth bulbs (study anthers later)	x-rays 160, 1640, 2560 r	sensitivity incr. toward metaphase	frequency of induced chromosome aberrations	Newcombe, 1942
Plant: *Trillium*	x-rays 50, 100, 200 r	anaphase	frequency of induced chromosome aberrations	Sparrow, 1944
Insect: grasshopper (*Chorthippus*)	x-rays	early prophase	frequency of induced chromosome aberrations	Creighton, 1941
Insect (*Sciara*) oocytes		metaphase and anaphase and just before fertilization	frequency of induced chromosome aberrations	Bozeman, 1943
Mouse lymphoma	x-rays neutrons	interphase; prophase next most sensitive	frequency of induced chromosome aberrations	Marshak, 1942

one sometimes finds differences in results. In some cases this is attributable to differences in materials; in other cases, even with the same materials, there is disagreement. Further discussion is withheld until other data and problems have been considered.

In retarding the rate of division or delaying the onset of mitoses in cells the radiations might act on the cytoplasm, the nucleus, or both. All three points of view have been taken. When in discussions the cytoplasm is pointed to as the seat of action of the radiations, it is usually found that Duryee's results on frog eggs are used to support the contention, although the author himself made no such claims. Duryee (1939) found that if the cytoplasm of enucleated frog eggs is given a dosage of 50,000r and the unirradiated nucleus is then returned to the cytoplasm, the same sort of chromosomal abnormalities appear as occur when the entire egg is irradiated. On the other hand, the nucleus, irradiated with the same dose in salt solution and then put back in untreated cytoplasm, shows no such defects. Interesting as these results may be, they do not bear directly on the problem of the retardation of cell division by x-rays, since tests of division of such cells have not been reported. It would be interesting to repeat this experiment with smaller dosages and to study the retardation of division. An apparently simple test object for the above experiment might appear to be a nucleus-free half of a sea urchin egg, which could be irradiated and inseminated with untreated sperm. Unfortunately, x-rays activate such fragments, and therefore insemination fails and the test cannot be made (E. B. Harvey, personal communication). If sperms are irradiated and then used to fertilize unirradiated eggs of frogs, salamander, trout, or sea urchins, the cleavage of such inseminated eggs is retarded. This has been taken as evidence of nuclear injury, since the sperm consists largely of nucleus. On the other hand, when the irradiation of the sperm is prolonged, the rate of cleavage may return to normal, and, in such cases, the sperm is believed to act only as an activating influence. The Hertwigs found that the sperm nucleus failed to enlarge and fuse with the egg nucleus after large dosages of x-rays, and in some cases the nuclei of the embryo appeared to be one-half the normal volume. Packard (1945) has reviewed most of these papers (see also Rugh and Exner, 1940; Henshaw, 1943). From all this work the conclusion has been drawn that the sperm interferes with and retards cleavage only when it attempts to fuse with the egg nucleus and that the interference is probably merely mechanical. In the converse experiment, when the egg is irradiated, the egg nucleus fails to function. After fertilization with untreated sperms, androgeny results, in which case the cleavage may be almost normal. This was demonstrated in the early experiments of the Hertwigs on the frog and was corroborated by chromosome counts made by Packard (1918) on *Chaetopterus* and by genetic data obtained by Whiting (1946) on the wasp *Habrobracon*. In wasps haploids give rise to males. In Whiting's experiment, the mother wasp was given such heavy doses of radiation that the egg nucleus failed to function. Since the sperm nucleus alone was present in each "zygote," the eggs gave rise to androgenic males, which reached maturity and were bred for genetic tests. It is obvious that if the effect of radiation is only on the cytoplasm, the sperm nucleus introduced into a heavily rayed egg should be rendered as abnormal as the egg nucleus, unless we assume a very short life of activation of the toxic materials produced by irradiation. The fact that the embryo develops indicates that the cytoplasmic injury does not interfere too seriously with the course of development of an untreated nucleus. With further irradiation beyond that required for inactivation of the egg nucleus, the cytoplasm is finally modified so that the sperm nucleus is no longer able to initiate division in it. Reiss (1925) has found that the relative resistance of nucleus and cytoplasm to short radiations, compared on the basis of such division-inhibiting injury, is 1:3.8 for x-rays and 1:8 for radium emanations.

No attempt is being made to minimize the changes in cytoplasm which may be induced in it by ionizing radiations. Some studies on changes in cytoplasmic properties have been made and indicate marked effects. Thus Mukerji (1929) finds that the mitochondria are destroyed and the Golgi apparatus swells. Packard (1931, 1945) and Scott (1937) have summarized the main changes seen in the cell as (1) a decline in respiration and a decline in glycolysis or no change at all; (2) an increase in acidity; and (3) an increase in viscosity. Wilbur and Rechnagel (1943) did not find such a change in viscosity in *Nereis* for dosages which markedly retard cleavage. Hubert (1929) has pointed out that the amount of radiation required to cause a marked decline of growth of the chick embryo has little effect on its respiration and gly-

colysis, much larger doses being required to affect the latter. Frankenthal and Back (1944) reported an increase in respiration in fowl erythrocytes after a very large dose. To what extent such changes can be correlated with retardation of cell division is still uncertain.

Nuclear changes following irradiation have been more intensively studied than cytoplasmic effects and an extensive literature upon the subject exists. Sax and Swanson (1941) have discussed the desirability of recognizing two fundamentally different types of effects of ionizing radiations on nuclei: (1) permanent changes in the morphology of chromosomes, such as breaks, deletions, and gross alterations, as well as point changes or mutations; and (2) temporary cessation of mitosis and clumping of chromosomes in metaphase and anaphase. Lea (1947) has discussed and analyzed the literature on the types of effects listed under (1); therefore only a brief reference to these studies need be made here. Under certain conditions reconstitution of chromosome splits occurs, e.g., under the action of centrifugation, at higher temperatures as contrasted to low, under the influence of ultraviolet radiation, and also under conditions in which nucleic acid is being condensed on the chromosomes (Kaufmann, 1946; Kaufmann and Hollaender, 1946; Kaufmann, Hollaender, and Gay, 1946). Otherwise the breaks are permanent. Lea regarded the bulk of the evidence as pointing toward breakage resulting from the action of single ionizing particles (target theory). A single particle may break two chromosomes at the same time (isochromatic breaks), if the chromatids lie close together and the pathway of the ionizing particle is sufficiently long.

The breakage of the chromosome leads to rearrangements and attachments which produce changes in heredity. Consideration of these effects or of mutations is outside the scope of this paper and good reviews of the subject already exist (Catcheside, 1945; and in press). However, it is to be hoped that studies on the physiological effects of x-rays and a better understanding of the chemical changes in the chromosomes produced by the ionizing radiations will ultimately lead to a better understanding of what a gene change is and how the chromosome is split by a "hit."

Two types of changes in chromosome chemistry have been postulated, in order to explain some of the physiological effects of x-rays: (1) depolymerization of the nucleic acid, leading to stickiness and clumping of chromosomes (Darlington, 1942), and (2) interference with nucleic acid production or its conversions (Mitchell, 1942a, b, 1943; von Euler and Hevesy, 1944; Hevesy, 1945).

There is now good evidence that ionizing radiations depolymerize nucleic acids in vitro (Sparrow and Rosenfeld, 1946; Taylor, Greenstein, and Hollaender, 1947). In the latter study it has been shown that no ammonia or inorganic phosphorus is split off, nor do any titratable acid groups appear. No purine or pyrimidine fragments small enough to pass through a dialyzing membrane appear, and the ultraviolet absorption spectrum remains the same as in the control. Although, as this indicates, the nucleic acid is not fragmented, its structural viscosity decreases; therefore the most likely change to have occurred is depolymerization. If this does occur, the fragments must still be larger than 10,000 in molecular weight. Since the thymonucleic acid units in flat platelets are believed to be oriented across the protein fibers (as indicated by studies with polarized light), depolymerization might well produce a disorganization in the nucleic acid that would result in interference in the movements of the chromosomes, as postulated by Darlington (1942).

Interference with the production and interconversions of nucleic acids has been the subject of a number of studies. The additional nucleic acid and protein needed by a cell undergoing mitosis is produced in the cell during the mitotic cycle. Nucleic acids are believed to be necessary for protein synthesis. A change in concentration of thymonucleic acid may be followed cytologically, owing to the difference in stainability of ribose (yeast) and desoxyribose (thymus) nucleic acids, the latter, only, being positive in the Feulgen reaction. While staining reactions are subject to error and difficult to use quantitatively, the general conclusions are probably acceptable provided proper precautions have been taken. Langendorff and Langendorff (1933) found a reduction in Feulgen stainability of chromatin following x-ray treatment. Mitchell (1942a, b, 1943) has found that radiations stop the formation of thymonucleic acid, and ribonucleic acid then accumulates. It is thought that thymonucleic acid, in the complex form in which it exists in the cell, arises from the polymerization of desoxyribose nucleotides. Desoxyribosenucleotides arise from ribosenucleotides by an enzymatically catalyzed reduction. Mitchell held that the enzyme catalyzing this reaction is inactivated by x-rays. On the basis of the absorption of the ions in the cells, Mitchell calcu-

lated that the ionic efficiency of the inactivation, on the basis of the inhibition of the reduction of the nucleotides, is of the order of 10^2 to 10^5. This means either that an enzyme has been inactivated or that a chain reaction is occurring. Since the latter is unlikely, the former seems probable. As a result of the destruction of the enzyme the ribosenucleotide accumulates, as can be ascertained by the ultraviolet photographs, since the ultraviolet is absorbed equally well by both ribose and desoxyribose nucleotides. Von Euler and von Hevesy (1944) have described a similar course of events in Jensen sarcoma following x-raying. Hevesy (1945) used radioactive phosphorus to tag the nucleic acids for similar studies.

On the basis of the above theory, Hevesy (1945) has attempted to explain the radiosensitivity of young or active tissues as compared to old or static tissues. Young, active tissues have a high thymonucleic acid requirement; therefore serious interference with their activities results from the inactivation of the enzyme or enzymes concerned in the synthesis of this compound. A static tissue requires less of such nucleic acids; therefore blockage of their synthesis does not produce such serious results, and we say that the tissue is radioresistant. Actually, in chemical terms, the initial damage is the same, but there is adequate time for recovery to occur before the cell has need of the nucleic acids. This is not true in young tissues, even if the rate of recovery were the same in both cases, since the cells are much more active.

The desoxyribosenucleotide not only must be formed but must be polymerized into nucleic acid. Perhaps the enzyme catalyzing this reaction is also affected, but there is no way of determining this, since the reaction will not occur if the precursor is lacking. Whatever the final analysis, these workers are inclined to attribute the various effects of radiations as resulting from their action on the enzymes engaged in syntheses. The possibility of a selective action on enzymes is suggested by the sensitivity of sulfhydryl enzymes (Barron et al., 1947).

As to the exact mechanism of action of the ionizing radiations, there are two opposite points of view: (1) that the effect of the radiations is indirect and caused by the formation of active radicals in the water (e.g., Fricke, 1935, 1938; Weiss, 1945, 1946; Barron et al., 1947); (2) that the significant action of the radiations on chromosomes and genes is by direct hits (target theory) upon these structures (e.g., Catcheside and Lea, 1943; Fano and Demerec, 1944; Catcheside, 1945, and in press; Lea and Catcheside, 1946; Lea, 1947). The test of these theories lies in the degree to which they explain the facts of radiochemistry and radiobiology. It is probable that some of the actions of ionizing radiations on cells may be best explained by one theory, some by the other.

In developing the theory of indirect action, Weiss has based his arguments on the radiochemistry of water (Weiss, 1941, 1944) and of various biochemical compounds, including enzymes, studied by Dale (1940, 1942, 1943a, b; Dale, Meredith, and Tweedie, 1943). Water is decomposed by x-radiations into hydrogen atoms and hydroxyl radicals:

$$H_2O + \text{x-radiations} \rightarrow H + OH$$

The reactions which occur in water will depend upon the other molecules present; in the absence of any other species of molecule, the hydrogen and hydroxyl radicals will recombine to form water. The speed of this recombination will depend upon the density of ionization. If other species of molecules are present, other reactions will occur, since atomic hydrogen is a powerful reductant and the hydroxyl radical is a powerful oxidant. Thus in the presence of oxygen, peroxide is formed (Risse, 1929, 1930; Fricke, 1935; Taylor, Thomas, and Brown, 1933; Weiss, 1944, 1946).

$$H + O_2 \rightarrow HO_2$$
$$2HO_2 \rightarrow H_2O_2 + O_2$$
$$H_2O_2 + H \rightarrow H_2O + OH$$
$$H_2O_2 + OH \rightarrow HO_2 + H_2O$$
$$H_2O_2 + O_2^- \rightarrow O_2 + OH + OH^-$$

When other materials are present other reactions will occur. An enzyme may be oxidized by the hydroxyl radical. In the cell such an oxidation might lead to the inactivation of the enzyme and injury to the cell. If the enzyme destroyed were one catalyzing the reduction of ribosenucleotide, desoxyribosenucleotide would no longer be formed, and interference with cell division would result.

Some of the best evidence in support of the theory of the indirect action of ionizing radiations is provided by the data of Barron, Dickman, and Singer (1947), which demonstrate clearly that the action of ionizing radiations on sulfhydryl enzymes such as, e.g., phosphoglyceraldehyde dehydrogenase, is a reversible oxidation. Addition of the reducing compound glutathione reactivates the enzymes. It is thought that the sulfhydryl group

is the one that is affected in the enzymes, since, when this group is chemically bound, irradiation does no harm. The active enzyme can be recovered from the irradiated solution by releasing the chemical binding. Proof that part of the action of the radiations is by hydrogen peroxide comes from the experiments in which catalase is added before irradiation to the enzyme being tested. Catalase breaks down the peroxide formed and thus protects the sulfhydryl enzyme from oxidation by peroxide. The extent to which protection occurs is a measure of the activity of peroxide. The remainder of the effect is attributed to the hydroxyl radicle. Prolonged irradiation results in irreversible inactivation of the enzymes. This may be due to further oxidation, but it may also be due to direct action of the radiations on the enzyme.

One of the best arguments for indirect action is the fact that dilution of the solute leads to a greater effectiveness of a given dosage of radiations (Fricke, 1935, 1938; Dale, 1940, 1943a, b). This can only be interpreted as being due to the greater availability of radicals and atoms in the water. It cannot be explained on the basis of direct hits on the solute, since the probability of such hits decreases with dilution. Similar results have been obtained with a number of compounds including acetylcholine, proteins, and an enzyme.

The phenomenon of "protection" also seems best explained on the basis of indirect action. By protection is meant the lesser effectiveness of radiations on a given solute or organism in the presence of other solutes. Thus acetylcholine is protected by glucose (Dale, 1943a); viruses, protozoa, and sperms are protected by proteins (Luria and Exner, 1941; Taylor, Thomas, and Brown, 1933; Evans and Slaughter, 1941; and Evans, Slaughter, Little, and Failla, 1942). Presence of additional solutes protects by the inactivation of hydrogen atoms and radicals. Protection cannot be explained on the basis of direct hits, since the presence of extraneous material does not lessen the probability of a hit upon a given enzyme, virus, or cell.

The difference in action between x-rays of different wavelengths, alpha particles, and neutrons is also best explained by their indirect action, according to Weiss. Thus Timofeeff-Ressovsky and Zimmer (1938) found fast neutrons less effective than x-rays or γ rays for producing mutations in *Drosophila*, and while killing of bacteria is relatively constant over a wide span of wavelengths, the efficiency drops off when soft x-rays or particles are used (Wyckoff, 1930a, b). Sievert (1940) made calculations of ionization in tissues and Gray, Read, and Poynter (1943) have given the number of ions per micron of path in tissues as 11, 56, 1200, and 3700 ion pairs for gamma, x-rays, neutrons, and alpha particles respectively. When the density of ionization is very great, as in the last two cases, there is likelihood of considerable recombination of hydrogen atoms and hydroxyl radicals; therefore relative inefficiency is to be expected. The density of ionization also increases when "soft" x-rays are used, and recombination might similarly account for their inefficiency. A word of caution with regard to action of neutrons is necessary. Neutrons have been considered more effective than x-rays (Lawrence and Lawrence, 1936; Zirkle and Aebersold, 1936; Lawrence, Aebersold, and Lawrence, 1936; Gray and Read, 1942; Spear, 1944) in some studies. Dempster (1941) found them more effective in producing dominant lethals and translocations, but less effective for recessive lethals. Timofeeff-Ressovsky and Zimmer (1938) found them less effective for producing mutations in *Drosophila*. Lea and Catcheside (1945) have considered this problem carefully and have concluded that in inducing sex-linked lethals the efficiency per ionization diminishes with increase in ion density. One other discrepancy in the comparison of effects of radiations of different wavelengths is the inefficiency of the very short x-rays produced by 500 KV or over. Thus while *Drosophila* eggs respond equally over a wide range of x-ray wavelengths, there is a decline in effectiveness of 500 KV x-rays (Packard, 1940, 1945). Similar results have also been observed for effects on the skin (Glasser, Quimby, Taylor, and Weatherwax, 1945) and for lethal effects on mice (Quastler and Clark, 1945). The latter workers used 20 million volt x-rays produced by a betatron (in which electrons are accelerated in an electromagnetic field before striking the target). The ions being widely spaced, there is an even lesser probability of their recombination than for softer x-rays; therefore their inefficiency remains unexplained. However, it should be pointed out again that the measurement of ionization from very short-wave x-rays offers difficulties, and the biological inefficiency may be only apparent. The rapid recovery of cells inhibited in early stages of mitosis by moderate doses of ionizing radiations suggests some sort of change which is rapidly reversed, perhaps in

oxidation of enzymes such as that described by Barron et al. (1947). Lea (1947) has pointed out that for each equal increment of dosage the increment of retardation of division is reduced. This has led him to formulate the concept of cumulative dose, which allows for the radiations the cell has received and the recovery which has occurred during the course of the irradiation. Henshaw and Francis (1933) and Henshaw, Henshaw, and Francis (1933) found a rapid recovery in sea urchin eggs. While they interpreted the recovery as being due to the elimination by diffusion of some toxic material, Lea has thought it more likely that something damaged in the cell is replaced and has found a quantitative formulation which agrees with the facts. Rapid replacement suggests some sort of reversible change rather than a rebuilding of new, complex units. Again, the evidence is not conclusive. Thus we see that while the theory of the indirect action of ionizing radiations will account for the fact of the reaction of radiations on chemicals in solution, its application is not nearly so clear-cut when applied to organisms. Certain other difficulties arise which will be discussed along with the theory of direct action (target theory).

The target theory, which holds that ionizing radiations act by direct action on solute molecules, was first developed in order to explain the exponential survival curve of enzymes and then of organisms (Hyssey and Thompson, 1923–24; Wyckoff, 1930a, b). Weiss (1946) has pointed out that the Glocker equations used in formulating the exponential survival curve can be derived just as well on the assumption that the effect of the radiation is due to the formation of hydroxyl radicals in the medium. Alone, therefore, the exponential survival curve does not constitute evidence for either theory. However, the target theory has much more support from the data of genetics and cytogenetics (Fano and Demerec, 1944; Catcheside, 1945, and in press; Lea and Catcheside, 1946; Opatowski, 1945, 1946; Lea, 1943, 1947). Some of these data can also be explained by the theory of indirect action just as well; some of them cannot. Thus the decrease in effectiveness per equivalent dose of different radiations, from the gamma rays and hard x-rays to soft x-rays, neutrons, and alpha particles, is explained on the target theory by the fact that as the density of ionization progressively increases in this series much of the ionization is wasted, being in excess of that required for the effect. On the indirect action theory, it is explained as being due to recombination of the radicals produced.

The independence of intensity of many effects of ionizing radiations and the independence of fractionation of the dosage favor the target theory. If a hit scores an effect, it is a discrete event and independent of the event which follows. However, the indirect action theory demands that a given concentration of reagent be reached before a reaction can occur. Permanence of cytogenetic effects and the slow recovery from other types of x-ray injury also suggest destruction or irreversible alteration of important biocatalysts, e.g., recovery from sensitization to heat produced by x-rays. By heat sensitization is meant such a change in the protoplasm that a dosage of heat which would not affect a control, kills the irradiated cell. Application of the same amount of heat before raying has no effect. Recovery of normal resistance to heat following raying is slow and requires three or more days. Furthermore, it does not occur unless the paramecia are fed (Giese and Heath, in press).

Perhaps the most convincing evidence comes from studies on induced chromatid exchanges. In *Tradescantia* the yield of these with neutrons and α particles has been shown to increase linearly with the dose, but for x-rays it increases with the square of the dose. Since the path of neutrons is such as generally to produce isochromatid breaks, one might expect linearity. But with x-rays the chances of exchanges increase with the increase in number of chromatids broken, an x-ray being enough to break one chromatid and only much less frequently enough to break two. These results can hardly be explained satisfactorily by the indirect action theory (Catcheside, in press; Lea, 1947).

Since some of the facts are explained by the target theory (e.g., cytogenetic effects listed above), others by indirect action of radiations (e.g., chemical effects, protection) and still others equally well by either theory (e.g., exponential survival curve), it is not possible at present to make a choice between them. Ionizing radiations may act directly as well as indirectly on the same cells at the same time. Thus the cytogenetic effects may be due to direct action whereas the more readily reversible "physiological effects" (as classified by Sax and Swanson, 1941) may be due to indirect action.

There remain biological effects of x-rays which

are not explained by any theory. Thus—why should there be a difference in susceptibility such that a few hundred roentgens will kill a human being whereas 600,000r are necessary to kill paramecia? A whole spectrum of resistance to x-radiations exists. Yet presumably all protoplasm is of similar density, and therefore absorption occurs to a similar degree in all cases. Secondly, all protoplasm contains approximately 80 per cent of water and 15 per cent of protein. If the effects of x-rays are due merely to ionizations of water or to hits at sensitive areas, the susceptibility of organisms should be rather similar. There must also be some feature of biological organization which has, up to the present, escaped the discernment of the experimenter, and which may hold a clue to the fundamental nature of radiobiological action.

Part of the work for this review was done while the author was a Guggenheim fellow at the California Institute of Technology, Pasadena, California.

SUMMARY

The absorption of radiowaves by tissues and solutions of electrolytes results in the production of heat. Within viable limits, up to a given optimum, cell division is accelerated by such a rise in temperature. Most workers claim that this is the only way in which radiowaves affect organisms. Others claim that some specific photochemical effect of radiowaves is observed, but the evidence is in no case conclusive.

The absorption of infrared radiations by an organism raises its temperature, and the rate of biological reactions, including cell division, is increased. If the temperature rises to a critical value, cell activities slow down and cease, due to a reversible denaturation of enzymes. Beyond this value irreversible coagulation and death ensue. For different organisms the critical temperature varies; thus in thermophilic forms it is far above the usual values. Organisms have also been observed to accommodate slowly to elevated temperatures. Proteins are protected against heat by the presence of certain fatty acids. The possibility exists that in thermophilic forms a similar protective agent is present, but it has not yet been studied. The possibility of specific photochemical effects of infrared rays is indicated.

Absorption of visible light results not only in the development of heat but also leads to specific photochemical effects. Light has no effect on colorless organisms or cells except in the presence of a photodynamic dye, in which event cell division is retarded. Division of pigmented cells may be retarded, as in the case of *Blepharisma*. Data on other pigmented cells and organisms are apparently not available.

Absorption of ultraviolet light results in many photochemical reactions, and absorption by the cell disrupts normal activities, the degree of disruption depending upon the amount of light absorbed. The division of cells is especially sensitive to such radiations, being retarded by minute amounts. On the basis of action spectrum studies, nucleoproteins appear to be the substances which absorb the radiations leading to retarded division. Cells are affected most readily in the prophase of division. At this time least desoxyribose nucleic acid is present, most being present in the metaphase. However, ultraviolet light does not distinguish between ribose and desoxyribose nucleic acids, both of which absorb ultraviolet equally well. At prophase the chromosomes, containing mainly ribose nucleic acids, are less compact, and therefore present a larger absorbing surface. A few studies indicate that an acceleration of cell division follows irradiation, but further studies with these forms are desirable.

The ionizing x-rays and γ rays, neutrons, and particulate radioactive emanations lower the rate of cell division mainly by increasing the interval between divisions. It has been difficult to decide by experiment which phase in mitosis is most susceptible, although prophase and metaphase have been singled out by most workers. A new approach, at present a center of attention, regards cell injury as due to interference with enzymic reactions concerned in the development of thymonucleic acid from ribose nucleotides. Both of the two steps involved—reduction of the ribose to the desoxyribose nucleotide, and the polymerization of the latter to thymonucleic acid—may be affected by the radiations, since in either case staining intensity (with Feulgen) would fall. Such interference is much more likely than interference with respiration or other cell functions, since the rate of cell division is much more readily affected than any of the other activities studied.

Two theories of the mechanism of action of ionizing radiations have arisen—that of direct action (target theory) and that of indirect effect by ionization of water. Chemical studies with solutes in dilute solution favor the latter theory.

Protection of organisms against x-rays, afforded by the presence of proteins or other chemicals in the medium, may be explained in a similar manner. However, specific effects such as gene mutations and effects on chromosomes are thought to be due to direct hits. Less specific effects, such as delay in cleavage, may be due to indirect as well as to direct action of the radiations.

LIST OF LITERATURE

ALPATOV, N. V., and D. K. NASTIUKOVA. 1932. The effect of various ultraviolet ray exposures on the division rate in *Paramecium*. *C. r. Acad. Sci. U.S.S.R.*, 1: 290–291.

——, and ——. 1933. The influence of different quantities of ultraviolet radiation on the division rate of *Paramecium*. *Protoplasma*, 18: 281–285.

——, and ——. 1934. On the susceptibility of infusoria as related to the colloidal properties of their protoplasm changed by means of different physico-chemical methods. *C. r. Acad. Sci. U.S.S.R.*, 3: 595–600.

ARNOW, L. E. 1936. Effects produced by irradiation of proteins and amino acids. *Physiol. Rev.*, 16: 671–685.

BACHEM, A. 1935. Selective heat production by ultra short (Hertzian) waves. *Arch. phys. Ther., X-ray, Radiol.*, 16: 645–650.

BACK, A., and L. HALBERSTAEDTER. 1945. Influence of biological factors on the form of roentgen ray survival curves. Experiments on *Paramecium caudatum*. *Amer. J. Roent. Radium* Ther., 54: 290–295.

BALLOU, G. A., P. D. BOYER, and J. M. LUCK. 1945. The electrophoretic mobility of human serum albumin as affected by lower fatty acid salts. *J. biol. Chem.*, 159: 111–116.

BARRON, E. S. GUZMAN, S. DICKMAN, and T. P. SINGER. 1947. On the inhibition of enzymes by ionizing radiations. *Federation Proc.*, 6: 236.

BATEMAN, J. B. 1935. Mitogenetic radiation. *Biol. Rev.*, 10: 42–71.

BELEHRADEK, J. 1935. *Temperature and Living Matter*. (Protoplasma Monographien, 8.) Borntraeger, Berlin.

BERGONIE, J., and L. TRIBONDEAU. 1904. Action des rayons-x sur le testicule du rat blanc. *C. r. Soc. Biol., Paris*, 57: 400–402.

——, and ——. 1906. Interpretation de quelques resultat de la radio-therapie et essai de fixation d'une technique rationelle. *C. r. Acad. Sci., Paris*, 142: 983–985.

BLUM, H. F. 1943. Some fundamental aspects of tumor development illustrated by studies with ultraviolet radiations. *J. Natl. Cancer Inst.*, 3: 569–581.

BOVIE, W. T. 1913. A preliminary note on the coagultation of proteins by ultraviolet light. *Science*, 37: 24.

——, and D. M. HUGHES. 1918. The effect of quartz ultraviolet light on the rate of division of *Paramedium caudatum*. *J. med. Res.*, 39: 223–231.

BOYER, P. D., G. A. BALLOU, and J. M. LUCK. 1946. The combination of fatty acids and related compounds with serum albumin. II. Stabilization against urea and guanidine denaturation. *J. biol. Chem.*, 162: 199–208.

——, F. G. LUM, G. A. BALLOU, J. M. LUCK, and R. G. PRICE. 1946. The combination of fatty acids and related compounds with serum albumin. I. Stabilization against heat denaturation. *J. biol. Chem.*, 162: 181–198.

BOZEMAN, M. L. 1943. Effects of irradiation of oöcytes of *Sciara*. *Genetics*, 28: 71. (Abstract).

BREITWEISER, C. J. 1935. Analysis of selective effects of short wave therapy. *Arch. phys. Ther.*, X-rays, Rad. 16: 594–598.

BRODE, W. R. 1941. *Chemical Spectroscopy*. Wiley, New York.

BURTON, A. C. 1936. The basis of the principle of master reactions in biology. *J. cell. comp. Physiol.*, 9: 1–14.

BUSCHKE, W., J. S. FRIEDENWALD, and S. G. MOSES. 1945. Effects of ultraviolet irradiation of corneal epithelium mitosis, nuclear fragmentation, post traumatic cell movements, loss of tissue cohesion. *J. cell. comp. Physiol.*, 26: 147–164.

CANTI, R. G., and M. DONALDSON. 1926. Effect of radiations on mitosis in vitro. *Proc. Roy. Soc.*, B, 100: 413–419.

——, and F. G. SPEAR. 1928. Effect of gamma radiation on dividing cells. *Proc. Roy. Soc.*, B, 102: 92–101.

——, and ——. 1929–30. Effect of gamma radiation on cell division in tissue culture. *Proc. Roy. Soc.*, B, 105: 93–99.

CARPENTER, D. C. 1940. Splitting the CONH linkage by means of ultraviolet light. *J. Amer. Chem. Soc.*, 62: 289–291.

——. 1941. Irradiation of proteins (by ultraviolet light causing photolysis). *J. Franklin Inst.*, 232: 76–85.

CARLSON, J. G. 1940. Immediate effects of 250r of x-rays on the different stages in mitosis in neuroblasts of the grasshopper *Chortophaga viridifasciata*. *J. Morph.*, 66: 11–23.

——. 1941. Effects of x-radiation on grasshopper chromosomes. *Cold Spring Harbor Symp. quant. Biol.*, 9: 104–112.

——. 1942. Immediate effect of 31r of x-rays on the

different stages in the mitosis of neuroblasts of *Chortophaga*. *J. Morph.*, 71 449–462.

CARLSON, J. G., and A. HOLLAENDER. 1944. Immediate effects of low doses of ultraviolet radiation of wavelength 2537A on mitosis in the grasshopper neuroblast. *J. cell. comp. Physiol.*, 23: 157–166.

——, and ——. 1945. Intensity effects of ultraviolet radiation of wavelength 2537A on mitosis in the grasshopper neuroblast. *J. cell. comp. Physiol.*, 26: 165–173.

CASPERSSON, T. 1936. Über den chemsichen Aufbau des Strukturen des Zellkernes. *Skandinav. Arch. Physiol.*, Suppl. 73, No. 8, 1–151.

——. 1940. Die Eiweissverteilung in den Strukturen der Zellkerne. *Z. Zellforsch. mikr. Anat.*, B, 1: 562–604.

——. 1940. Nukleinsäureketten und Genvermehrung. *Z. Zellforsch. mikr. Anat.*, 1: 605–619.

——. 1941. Cytoplasmonukleotide in eiweissproduzierenden Druzenzellen. *Z. Zellforsch. mikr. Anat.*, 2: 111–131.

——, H. LANDSTROM-HYDEN, and L. AQUILONIUS. 1941. Cytoplasmonukleotide in Eiweissproduzieren den Drusezellen. *Z. Zellforsch. mikr. Anat.*, 2: 111–131.

——, and J. SCHULTZ. 1940. Ribonucleic acid in both nucleus and cytoplasm and the function of the nucleolus. *Proc. Natl. Acad. Sci.* Wash., 26: 507–515.

——, and B. THORELL. 1941. Der endozelluläre Eiseiss und Nukleinsäure Stoffwechsel in embryonalem Gewebe. *Z. Zellforsch. mikr. Anat.*, 2: 132–154.

CATCHESIDE, D. G. 1945. Effects of ionizing radiations on chromosomes. *Biol. Rev.*, 20: 14–28.

——. 1948, In press. Genetic Effects of Radiations. In *Advances in Genetics*, 2, M. Demerec, ed. Academic Press, New York. 1948. (Made available by courtesy of the author.)

——, and D. E. LEA. 1943. The effect of ionization distribution on chromosome breakage by x-rays. *J. Genet.*, 45: 186–196.

CHASE, H. Y. 1937. The effect of ultraviolet light upon early development in the egg of *Urechis caupo*. *Biol. Bull.*, 72: 377–383.

——. 1938. The effect of ultraviolet light upon cleavage in certain marine eggs. *Biol. Bull.*, 75: 134–144.

CLARK, J. H. 1935. The denaturation of egg albumin by ultraviolet radiation. *J. gen. Physiol.*, 19: 199–210.

CRABTREE, H. G., and W. CRAMER. 1933. The action of radium on cancer cells. I. Effects of hydrogen cyanide, iodoacetic acid and sodium fluoride on the metabolism and the transplantability of cancer cells. II. Some of the factors determining the susceptibility of cancers to radium. *Proc. Roy. Soc.*, B, 113: 226–238; 238–250.

CREIGHTON, M. 1941. The effect of x-rays on mitotic and meiotic chromosomes and cell division in *Chorthippus longicornis* (Orthoptera). *J. exp. Zool.*, 87: 347–369.

CROZIER, W. J. 1924. On the possibility of identifying chemical processes in living matter. *Proc. Natl. Acad. Sci. Wash.*, 10: 461–464.

——. 1926a. Note on the distribution of critical temperatures for biological processes. *J. gen. Physiol.*, 9: 525–529.

——. 1926b. The distribution of temperature characteristics for biological processes; critical increments for heart rates. *J. gen. Physiol.*, 9: 531–546.

DALE, W. M. 1940. The effect of x-rays on enzymes. *Biochem. J.*, 34: 1367–73.

——. 1942. The effects of x-rays on the conjugated protein d-aminoacid oxidase. *Biochem. J.*, 36: 80–85.

——. 1943a. Effects of x-rays on acetylcholine solution showing the dilution and protection phenomena found for enzymes. *J. Physiol.*, 102: 50–54.

——. 1943b. Effects of x-rays on aqueous solutions of biologically active compounds. *Brit. J. Radiol.*, n. s., 16: 171–172.

——, W. J. MEREDITH, and M. C. K. TWEEDIE. 1943. Mode of action of ionizing radiations in aqueous solutions. *Nature, Lond.*, 151: 280–281.

DALLINGER, W. H. 1882. On a series of experiments to determine the thermal death point of known Monad germs when the heat is endured in a fluid. *J. roy. micros. Soc.*, 10: 177–188.

DARLINGTON, C. D. 1942. Chromosome chemistry and gene action. *Nature Lond.*, 149: 66–69.

——, and L. F. LACOUR. 1945. Chromosome breakage and the nucleic acid cycle. *J. Genet.*, 46: 180–267.

DAVIS, B. D., A. HOLLANDER, and J. P. GREENSTEIN. 1942. Electrophoretic patterns, colloid osmotic pressure and viscosity of serum denatured by ultraviolet radiation. *J. biol. Chem.*, 146: 663–7.

DEGARIS, C. F. 1927. A genetic study of *Paramecium caudatum* in pure lines through an interval of experimentally induced monster formation. *J. exp. Zool.*, 49: 133–145.

DEMPSTER, E. F. 1941. Dominant vs. recessive lethal mutation. *Proc. Natl. Acad. Sci. Wash.*, 27: 249–250.

DOBSON, R. L., and J. H. LAWRENCE. 1948. Physiological effects of radiant energy. *Ann. Rev. Physiol.*, 10 (in press).

DOWNES, A., and T. P. BLUNT. 1877. Researches on the effect of light upon bacteria and other organisms. *Proc. Roy. Soc.*, 26: 488–500.

DREYER, G. 1903. Die Einwirkung des Lichtes auf Amoeben. *Mitt. Finsens med. Lichtinst.*, 4: 81–107.

——. 1904. Untersuchungen über die Einwirkung

des Lichtes auf Infusarien. *Mitt. Finsens med. Licht Inst.*, 7: 98–131.

DUGGAR, B. 1936. *Biological Effects of Radiation*, 2 vols. McGraw Hill, New York.

DURYEE, W. R. 1939. Comparative effects of x-radiation on isolated and non-isolated nuclei. *Anat. Rec.*, 75: 144 (Suppl.).

ELLINGER, F. 1941. *The Biologic Fundamentals of Radiation Therapy*. Elsevier, New York.

EULER, H. VON, and G. VON HEVESY. 1944. Action of x-rays on nucleic acid metabolism in Jensen sarcoma. *Arch. Kem. Minerol. Geol.*, 17A (30): 1–66.

EVANS, T. C., and H. D. KERR. 1943. Modification of radiosensitivity of the skin. *Amer. J. Roent. Radium Ther.*, 50: 621–635.

—, and J. C. SLAUGHTER. 1941. Effect of sea water on the radiosensitivity of *Arbacia* sperm. *Collect. Net*, 16: 101; 113–114.

—, —, E. P. LITTLE, and G. FAILLA. 1942. Influence of the medium on radiation injury of sperm. *Radiology*, 29: 663–680.

FAILLA, G. A. 1939. A theory of the biological action of ionizing radiations. *Cancer Prob. Symp.*, 1929: 202–214.

—. 1940. Some aspects of ionizing radiations. Janeway lecture. *Amer. J. Roent. Radium Ther.*, 44: 649–664.

FANO, U., and M. DEMEREC. 1944. Genetics: physical aspects, pp. 495–512, in *Medical Physics*, O. Glasser, ed. Year Book Pub. Chicago.

FORSYTHE, W. E. 1937. *The Measurement of Radiant Energy*. McGraw Hill, New York.

FRANK, G., and A. GURWITSCH. 1927. Zur Frage der Identität mitogenetische und ultravioletter Strahlen. *Arch. Entwmech. Org.*, 109: 451–454.

FRANKENTHAL, L., and A. BACK. 1944. The effect of x-rays on the respiration of the fowl erythrocyte. *Biochem. J.*, 38: 351–354.

FRANKSTON, J. E. 1940. The photodynamic action of neutral red on *Triturus viridens*. *J. exp. Zool.*, 82: 161–190.

FRICKE, H. 1935. The chemical properties of x-ray activated molecules with special reference to the water molecule. *Cold Spring Harbor Symp. quant. Biol.*, 3: 55–65.

—. 1938. The denaturation of proteins by high frequency radiations. *Cold Spring Harbor Symp. quant Biol.*, 6: 164–170.

GALE, C. K. 1935. Penetration and selective heating effect of short and ultrashort waves (an experimental study with unicellular organisms and with electrolytes). *Arch. phys. Ther., X-ray, Radium*, 16: 271–277.

GATES, F. L. 1929a. A study of the bactericidal action of ultraviolet light. I. The reaction to monochromatic radiations. *J. gen. Physiol.*, 13: 231–248.

—. 1930. III. The absorption of ultraviolet light by bacteria. *J. gen. Physiol.*, 14: 31–42.

—. 1933. The reaction of individual bacteria to irradiation with ultraviolet light. *Science*, 77: 350.

GIERSCH, C. 1945. A growth-promoting factor produced by ultraviolet-irradiation of *Stichococcus bacillaris* Naegeli and *S. flaccidus* (Kutz) Gay. *Stud. Inst. Divi Thomae*, 4: 51–58.

GIESE, A. C. 1938a. The effects of ultraviolet radiations of various wavelengths upon cleavage of sea urchin eggs. *Biol. Bull.*, 75: 238–247.

—. 1938b. Cannibalism and gigantism in *Blepharisma*. *Trans. Amer. Micros. Soc.*, 57: 245–255.

—. 1939a. Ultraviolet radiation and cell division. Effects of λ 2654 and 2804A upon *Paramecium caudatum*. *J. cell. comp. Physiol.*, 13: 139–150.

—. 1939b. Ultraviolet radiation and cell division. Nuclear sensitivity: effect of irradiation of sea urchin sperm. *J. cell. comp. Physiol.*, 14: 371–382.

—. 1939c. Retardation of early cleavage of *Urechis* by ultraviolet light. *Physiol. Zool.*, 12: 319–327.

—. 1945a. Ultraviolet radiations and life. *Physiol. Zool.*, 18: 223–250.

—. 1945b. The ultraviolet action spectrum for retardation of division of *Paramecium*. *J. cell. comp. Physiol.*, 26: 47–55.

—. 1946a. An intracellular photodynamic sensitizer. *J. cell. comp. Physiol.*, 28: 119–127.

—. 1946b. Comparative sensitivity of sperms and eggs to ultraviolet radiations.. *Biol. Bull.*, 91: 81–87.

—, and R. H. ALDEN. 1938. Cannibalism and giant formation in *Stylonychia*. *J. exp. Zool.*, 78: 117–134.

—, and B. B. CROSSMAN. 1945. The action spectrum and sensitization to heat with ultraviolet light. *J. gen. Physiol.*, 29: 79–87.

—, and E. A. REED. 1940. Ultraviolet radiation and cell division. Variation in resistance to radiation with stock, species and nutritional differences in *Paramecium*. *J. cell. comp. Physiol.*, 15: 393–408.

GLASSER, O. 1933. *The Science of Radiology*. Chas. C. Thomas, Springfield, Ill.

—, E. H. QUIMBY, L. S. TAYLOR, and J. L. WEATHERWAX. 1944. *Physical Foundations of Radiology*. Hoeber, New York.

GOODRICH, J. P. 1943. Experimental modification of radiosensitivity of embryonic cells. *Radiology*, 40: 179–187.

GOSSET, A., A. GUTTMANN, G. LAKHOVSKY, and I. MAGROU. 1924. Essai de therapeutique du "Cancer experimentale" des plantes. *C. r. Soc. Biol., Paris*, 91: 626–628.

GRAY, L. H. 1946. Comparative studies of the biological effects of x-rays, neutrons and other ionizing radiations. *Brit. med. Bull.*, 4: 11–18.

GRAY, L. H., and J. READ. 1942. The effect of ionizing radiations on the broad bean root. III. The lethal action of neutron radiation. *Brit. J. Radiol.*, 15: 72–76.

——, ——, and M. POYNTER. 1943. The effect of ionizing radiations on the broad bean root. *Brit. J. Radiol.*, 16: 125–128.

GREENSTEIN, J. P. 1944. Nucleoproteins, in *Advances in Protein Chemistry*, II, M. L. Anson and J. T. Edsall, eds., pp. 209–289, Academic Press, New York.

——, and W. V. JENRETTE. 1941. Physical changes in thymonucleic acid induced by proteins, salts, tissue extracts and ultraviolet radiation. *Cold Spring Harbor Symp. quant. Biol.*, 9: 236–254.

GRIMALDI, A. 1934. Sul meccanismo di azione della onde hertziane di breve lunhezza sugli organismi viventi. *Scritti Biol.*, 9: 333–335.

GURWITSCH, A., and L. GURWITSCH. 1934. *L'Analyse Mitogenetique Spectrale.* Hermann, Paris.

HAASE, W., and E. SCHLIEPHAKE. 1931. Versuche über den Einfluss kurzer electrischer Wellen aus des Wachstum von Bakterien. *Strahlentherapie*, 40: 133–158.

HALBERSTAEDTER, L., and A. BACK. 1942. The effect of x-rays on single colonies of *Pandorina*. *Brit. J. Radiol.*, 15: 124–128.

HANCE, R. T., and H. CLARK. 1925. The effect of x-rays of the division rate of *Paramecium*. *J. exp. Med.*, 43: 231–240.

HASCHE, E., and H. LUNIG. 1934. Zur Dosierungsfrage in der Ultrakurzwellen Therapie. *Strahlentherapie*, 50: 351–356.

HEILBRUNN, L. V. 1924. The colloid chemistry of protoplasm. IV. Heat coagulation of protoplasm. *Amer. J. Physiol.*, 69: 190–199.

——. 1943. *An Outline of General Physiology.* Saunders, Philadelphia.

HENSHAW, P. S. 1938. The question of whether the delay in cleavage of *Arbacia* eggs produced by x-rays is caused by a general slowing of the cleavage process or by a block at some particular stage. *Biol. Bull.*, 75: 356 (Abstr.).

——. 1938b. The action of x-rays on nucleated and non-nucleated egg fragments. *Amer. J. Cancer*, 33: 258–264.

——. 1940. Further studies on the action of Roentgen rays on the gametes of *Arbacia punctulata*. II. Modification of the mitotic time schedule of the eggs by exposure of the gametes to Roentgen rays. *Amer. J. Roent. Radium Ther.*, 43: 907–912.

——. 1943. Peculiar lesions in frogs induced by irradiation of sperm with x-rays. *J. Natl. Cancer Inst.*, 3: 409–417.

——. and I. COHEN. 1940. Further studies on the action of roentgen rays on the gametes of *Arbacia punctulata*. *Amer. J. Roent. Radium Ther.*, 43: 899–933.

——, and D. S. FRANCIS. 1936. The effect of x-rays on cleavage in *Arbacia* eggs: evidence of nuclear control of division rate. *Biol. Bull.*, 70: 28–35.

——, and C. T. HENSHAW. 1933. Changes in susceptibility of *Drosophila* eggs to x-rays. A correlation of changes in radiosensitivity with stages in development. *Radiology*, 21: 239–251.

——, C. T. HENSHAW, and D. S. FRANCIS. 1933. The effect of roentgen rays on the time of the first cleavage in marine invertebrate eggs. II. Differential recovery and its influence when different experimental methods are used. *Radiology*, 21: 533–544.

HEVESY, G. 1945. On the effect of Roentgen rays on cellular division. *Rev. mod. Physics*, 17: 102–111.

HINRICHS, M. A. 1928. Ultraviolet radiation and division in *Paramecium caudatum*. *Physiol. Zool.*, 1: 394–415.

HOAG, J. B. 1939. The absorption of radio waves in water. *Science*, 90: 277–279.

HOAGLAND, H. 1937. "Master reactions" and temperature characteristics. *J. cell. comp. Physiol.*, 10: 29–36.

DENHOED, D. 1946. Biological aspects of the atomic bomb. *Nederl. Tijdschr. Geneeskunde*, 90: 61–64. C. A. 40: 3143.

HOLLAENDER, A. 1945. Abiotic and sublethal effects of ultraviolet radiation on microorganisms, (in *Aerobiology, A.A.A.S. Monogr.*, 17: 156–165), ed. Amer. Assoc. Adv. Sci., Washington.

——, and B. M. DUGGAR. 1938. The effects of sublethal doses of monochromatic ultraviolet radiation on the growth properties of bacteria. *J. Bact.*, 36: 17–37.

——, and C. W. EMMONS. 1941. The action of ultraviolet light on dermatophytes. Wavelength dependence of mutation production in the ultraviolet with special emphasis on fungi. *Cold Spring Harbor Symp. quant. Biol.*, 9: 179–186.

——, J. P. GREENSTEIN, and W. V. JENRETTE. 1941–42. Effect of ultraviolet radiation on sodium thymonucleate. *J. Natl. Cancer Inst.*, 2: 23–28.

——, E. R. SANSOME, E. ZIMMER, and M. DEMEREC. 1945. Quantitative irradiation experiments with *Neurospora crassa*. II. Ultraviolet radiations. *Amer. J. Bot.*, 32: 226–35.

——, and SCHREFFEL, E. 1931. Mitogenetic rays. *Quart. Rev. Biol.*, 6: 215–222.

HOLTHUSEN, H. 1921. Beitrage zur Biologie der Strahlenwirkung. *Pflüg. Arch. ges. Physiol.*, 187: 1–24.

HUBERT, R. 1929. Der Einfluss der Röntgenstrahlen auf die energieliefernden Reaktionen auf des wachsenden Gewebes. *Pflüg. Arch. ges. Physiol.*, 223: 333–350.

HUGHES, D. M., and W. T. BOVIE. 1918. The effect of fluorite ultraviolet light on the rate of division of *Paramecium caudatum*. *J. med. Res.*, 39: 233–238.

HUSSEY, R. G., and W. R. THOMPSON. 1923–24. The

effect of radioactive radiations and x-rays on enzymes. *J. gen. Physiol.*, 6: 1–5.

HUTCHINSON, A. H., and M. R. ASHTON. 1929. The specific effects of monochromatic light on the growth of *Paramecium*. *Can. J. Res.*, 1: 292–303.

JELLINEK, S. 1936. Biology of ultrashort waves. *Arch. phys. Ther., X-rays, Radium*, 17: 512–513.

JOHNSON, E. L. 1936. Susceptibility of several species of flowering plants to x-radiation. *Plant Physiol.*, 11: 319–342.

JOHNSON, F. H., H. EYRING, R. STEBLAY, H. CHAPLIN, C. HUBER, and G. GHERARDI. 1945. The nature and control of reactions in bioluminescence. *J. gen. Physiol.*, 28: 463–537.

JUNGLING, O., and H. LANGENDORF. 1930. Über die Wirkung verschieden hoher Röntgendosen auf den Kernteilungsablauf. *Strahlentherapie*, 38: 1–10.

KAHLER, H., W. H. CHALKLEY, and C. VOEGTLIN. 1929. The nature of the effect of a high frequency electric field on *Paramecium*. *U. S. Pub. Health* Rept., 44: 339–347.

KANITZ, A. 1915. *Temperatur und Lebensvorgänge*. Borntraeger, Berlin.

KAUFMANN, B. P. 1946. Modification of the frequency of chromosomal rearrangements induced by X-rays in *Drosophila*. III. Effect of supplementary treatment at the time of chromosome recombination. *Genetics*, 31: 449–453.

——, and A. HOLLAENDER. 1946. Modification of the frequency of chromosomal rearrangements induced by X-rays in *Drosophila*. II. Use of ultraviolet radiation. *Genetics*, 31: 368–376.

——, ——, and H. GAY. 1946. Modification of the frequency of chromosomal rearrangements induced by X-rays in *Drosophila*. I. Use of the near infra red. *Genetics*, 31: 349–367.

KEMP, T., and J. JUUL. 1932. Influence of ultraviolet rays upon mitoses in tissue culture. *Arch. Path. Mikrobiol. Skand.*, 9: 222–235.

KLER, S. 1925. Action de la lumière ultraviolette sure les fragments de coeur contractiles in vitro. *C. r. Soc. Biol.*, 93: 1391–4.

LANGENDORFF, H., and M. LANGENDORFF. 1931. Strahlenbiologische Untersuchungen an befruchteten Seeigeleiern. *Strahlentherapie*, 42: 793–799.

——, and ——. 1933. Über die biologisiche Wirkung von sehr grossen Röntgendosen. *Strahlentherapie*, 47: 723–726.

LARKIN, J. C. 1946. The distribution of radiation in the atomic bombing of Nagasaki. *Amer. J. Roent. Radium Ther.*, 55: 525–532.

LATARJET, R. 1943. Action du froid sur la reparation des radiolesions chez une levure et chez une bacterie. *C. r. Acad. Sci. Paris*, 217: 186–188.

LAWRENCE, J. H., P. C. AEBERSOLD, and E. O. LAWRENCE. 1936. Comparative effects of x-rays and neutrons on normal and tumor tissue. *Proc. Natl. Acad. Sci. Wash.*, 22: 543–557.

——, and E. O. LAWRENCE. 1936. The biological action of neutron rays. *Proc. Natl. Acad. Sci. Wash.*, 22: 124–133.

LEA, D. E. 1943. The spatial distribution of ionization in irradiated tissues and its relation to biological effects. *Brit. J. Radiol.*, 16: 338–339.

——. 1947. *Actions of Radiations on Living Cells*. Macmillan, New York.

——, and D. G. CATCHESIDE. 1945. The bearing of radiation experiments on the size of the gene. *J. Genet.*, 47: 41–50.

LEWIS, M. R. 1945. The injurious effect of light upon dividing cells in tissue culture containing fluorescent substances. *Anat. Rec.*, 91: 199–207.

LOOFBOUROW, J. R. 1947. Intercellular hormones. 7. Release of aminoacids by damaged living yeast cells. *Biochem. J.*, 41: 119–122.

——, E. S. COOK, and M. M. STIMSON. 1938. Chemical nature of proliferation-promoting factors from injured cells. *Nature* (*Lond.*), 142: 573.

——, and C. M. DWYER. 1939. Production of intercellular hormones. *Nature* (*Lond.*), 143: 725–726.

——, and M. N. MORGAN. 1938. Intercellular wound hormones from ultraviolet injured cells. *Stud. Inst. Divi Thomae*, 1: 137–153.

——, and A. G. CRONIN. 1941. Proliferation-promoting hormones. I. Evidence for their production by living cells as a response to injury. *Biochem. J.*, 35: 603–609.

——, ——, and M. M. LANE. 1940. Proliferation producing intercellular hormones. I. Quantitative study of factors produced by injured animal tissue cells. *Biochem. J.*, 34: 432–441.

——, M. E. ENGLERT, and C. M. DWYER. 1941. Increased yield of nucleic acid-like substances from irradiated yeast. *Nature* (*Lond.*), 148: 113.

——, and L. JOYCE. 1941. Increased ultraviolet absorption of cells following irradiation with ultraviolet light. *Nature* (*Lond.*), 148: 166.

——, S. OPPENHEIM-ERRERA, D. G. LOOFBOUROW, and C. A. YEATS. 1947. Intercellular hormones. 8. Release of nucleotides and nucleosides by damaged living cells. *Biochem. J.*, 41: 122–129.

——, A. M. WEBB, and R. K. ABRAMOWITZ. 1942. Relation of aeration to the activity of proliferation promoting action of injured cells. *Nature* (*Lond.*), 149: 272.

LORENZ, E. 1934. Search for mitogenetic radiation by means of the photoelectric methods. *J. gen. Physiol.*, 17: 843–862.

LURIA, S. E., and F. M. EXNER. 1941. The inactivation of bacteriophage by x-rays-influence of the medium. *Proc. Natl. Acad. Sci. Wash.*, 27: 370–375.

LUTHER, W. 1938. Radiosensibilität und Zellteilung. I. Versuche an Froscheiern. *Strahlentherapie*, 62: 436–449.

McClennan, J. C., and A. C. Burton. 1930. The heating of electrolytes in high frequency fields. *Can. J. Res.*, 3: 224–239.

——, and ——. 1931. Selective heating by short radio waves and its application to electrotherapy. *Can. J. Res.*, 5: 530–556.

MacDougall, M. S. 1929. Modification in *Chilodon uncinatus* produced by ultraviolet radiation. *J. exp. Zool.*, 54: 95–109.

——. 1931. Another mutation of *Chilodon uncinatus* produced by ultraviolet radiation with a description of its maturation processes. *J. exp. Zool.*, 58: 229–236.

McKinley, J., G. Murray, and J. G. McKinley, Jr. 1931. The vacuum tube oscillator in biology. *Quart. Rev. Biol.*, 6: 322–328.

Marshak, A. 1935. The effect of x-rays on chromosomes in different stages of meiosis. *J. gen. Physiol.*, 19: 179–198.

——. 1938. The stage of mitosis at which chromosomes are rendered less sensitive to x-rays by ammonia. *Proc. Soc. exp. Biol. Med.*, 39: 194–198.

——. 1942. Effects of x-rays and neutrons on mouse lymphoma chromosomes in different stages of the nuclear cycle. *Radiology*, 39: 621–626.

Matisse, G. 1919. Action de la chaleur et du froid sur l'activité des êtres vivants. These, Paris.

Mayer, E. 1932. *The Curative Value of Light.* Appleton, New York.

——. 1934. Über den Wirkungsmechanismus der Ultraviolettbestrahlung von mesenchymalen Gewebekulturen. *Arch. exp. Zellforsch.*, 16: 23–47.

——, and H. Schreiber. 1934. Die Wellenlangeabhängigkeit der Ultraviolettwirkung auf Gewebekulturen (Reinkulturen). *Protoplasma*, 21: 34–61.

Meier, F. E. 1939. Stimulative effect of short wavelengths of the ultraviolet on the alga, *Stichococcus bacillaris*. *Smithson. Misc. Coll.*, 98: 1–19.

Meier-Chase, F. E. 1941. Increased stimulation of the alga *Stichococcus bacillaris* by successive exposure to short wavelengths of the ultraviolet. *Smithson. Misc. Coll.*, 99: 1–16.

Miller, E. S. 1940. *Quantitative Biological Spectroscopy.* Burgess, Minneapolis.

Mirsky, A. E., and M. L. Anson. 1935. Sulfhydryl and disulfide groups of proteins. II. *J. gen. Physiol.*, 19: 427–259.

——, and L. Pauling. 1936. On the structure of native, denatured and coagulated proteins. *Proc. Natl. Acad. Sci. Wash.*, 22: 439–447.

——, and A. W. Pollister. 1942. Nucleoproteins of cell nuclei. *Proc. Natl. Acad. Sci. Wash.*, 28: 344–352.

Mitchell, H. K., and M. B. Houlahan. 1946. *Neurospora*. IV. A temperature sensitive riboflavin mutant. *Amer. J. Bot.*, 33: 31–35.

Mitchell, J. S. 1942a. Disturbance of nucleic acid metabolism produced by therapeutic doses of x and gamma radiations. II. Accumulation of pentosenucleotides in the cytoplasm. *Brit. J. exp. Path.*, 23: 296–309.

——. 1942b. III. Inhibition of synthesis of thymonucleic acid by radiations. *Brit. J. exp. Path.*, 23: 309–313.

——. 1943. Metabolic effects of therapeutic doses of x and gamma radiations. *Brit. J. Radiol.*, 16: 339–343.

Moppett, W. 1932. *Homogeneous X-radiation and Living Tissues.* Austral. Med. Publ. Co., Sidney.

Mortimer, B., and S. L. Osborne. 1935. Tissue heating by short wave diatherapy. Some biologic observations. *J. Amer. Med. Assoc.*, 104: 1413–1419.

Mukerji, R. N. 1929. Effect of x-radiation on the spermatogenesis of *Lepisma domestica*. *Proc. Roy. Soc.*, B, 105: 409–445.

Nelson, C., and S. C. Brooks. 1933. Effect of infra-red light on subsequent fertilization of the eggs of certain marine invertebrates. *Proc. Soc. exp. Biol. Med.*, 30: 1007–1009.

Newcomer, H. B. 1942a. The action of x-rays on the cell. I. The chromosome variable. *J. Genet.*, 43: 145–171.

——. 1942b. The action of x-rays on the cell. II. The external variable. *J. Genet.*, 43: 237–248.

Neurath, H., J. P. Greenstein, F. W. Putnam, and J. O. Erikson. 1944. The chemistry of protein denaturation. *Chem. Rev.*, 34: 157–265.

Opatowski, I. 1945. Chain processes and their biophysical application. I. General theory. *Bull. math. Biophysics*, 7: 161–180.

——. 1946. II. The effect of recovery. *Bull. math. Biophysics*, 8: 7–15.

Oster, R. H. 1934. The results of irradiating *Saccharomyces* with monochromatic ultraviolet light. I. Morphological and respiratory changes. *J. gen. Physiol.*, 18: 71–88.

Packard, C. 1916. The effect of radium radiations on the rate of cell division. *J. exp. Zool.*, 21: 199–212.

——. 1918. The effect of radium radiations on the development of *Chaetopterus*. *Biol. Bull.*, 35: 50–70.

——. 1931. The biological effects of short radiations. *Quart. Rev. Biol.*, 6: 253–280.

——. 1940. The biological measurement of high voltage radiations. *Radiology*, 34: 17–23.

——. 1945. Roentgen radiations in biological research. *Radiology*, 45: 522–533.

Patterson, E. K. 1941. The photodynamic action of neutral red on root tips of barley seedlings. I. The effect on frequency of cell division. *Amer. J. Bot.*, 28: 628–638.

PRZIBRAM, H. 1923. *Temperature und Temperaturen im Tierreiche.* Deuticke, Leipzig und Wien.

QUASTLER, H., and R. K. CLARK. 1945. Biological evaluation of 30 million volt roentgen rays. *Amer. J. Roent. Rad. Ther.*, 54: 723–727.

RAHN, O. 1936. *Invisible Radiations of Organisms.* (Protoplasma Monographien. Vol 9.) Borntraeger, Berlin.

REISS, P. 1925. Sur l'action comparée des rayons-x et du radium sur le noyau et le cytoplasme. *C. r. Soc. Biol. Paris*, 92: 1403–1406.

RISSE, O. 1929. Einige Bemerkungen zum Mechanismus chemischer Röntgenreactionen in wässrigen Lösungen. *Strahlentherapie*, 34: 578–581.

——. 1930. Die physikalische Grundlagen der chemischen Wirkungen des Lichtes und der Röntgenstrahlen. *Ergebn. Physiol.*, 30: 242–293.

RUGH, R., and F. EXNER. 1940. Development effects resulting from exposure to x-rays. II. Development of leopard frog eggs activated by bullfrog sperm. *Proc. Amer. Phil. Soc.*, 83: 607–617.

RYAN, F. J. 1941. Temperature change and the subsequent rate of development. *J. exp. Zool.*, 88: 25–54.

SAX, L. 1940. An analysis of x-rays induced chromosome aberrations in *Tradescantia*. *Genetics*, 25: 41–68.

——, and C. P. SWANSON. 1941. Differential sensitivity of cells to x-rays. *Amer. J. Bot.*, 28: 52–59.

SCHEREschewsky, J. W. 1928. The action of currents of very high frequency upon tissue cells. A. On a transplantable mouse sarcoma. *U. S. Pub. Health Rept.*, 43: 927–945.

SCHLIEP, W. 1923. Die Wirkung des ultravioletten Lichtes auf die morphologischen Bestandteile des Ascariseies. *Arch. Zellforsch.*, 17: 289–367.

SCHLIEPHAKE, E. 1935. *Kurzwellentherapie.* Fischer, Jena.

SCHULTZ, J., T. CASPERSSON, and L. AQUILONIUS. 1940. The genetic control on nucleolar composition. *Proc. Natl. Acad. Sci. Wash.*, 26: 515–517.

SCOTT, C. M. 1937. Some quantitative aspects of the biological action of x-rays. *Med. Res. Coun. Special Report Ser.*, 223.

SIEVERT, R. M. 1940. Determination of ionization in biological objects. *Acta Radiol.*, 31: 189–205.

SIZOVA, M. A. 1936. Structural changes in chromosomes induced by irradiation of physiologically modified cells. *C. r. Acad. Sci. U.S.S.R.*, 2: 197–198.

SONNE, C. 1929. The biological effects of the ultraviolet rays and the investigation as to the part of the spectrum they lie in. *Arch. phys. Ther., X-rays, Rad.*, 10: 239–252.

SPARROW, A. H. 1944. X-ray sensitivity changes in meiotic chromosomes and the nucleic acid cycle. *Proc. Natl. Acad. Sci. Wash.*, 30: 147–155.

——, and F. M. ROSENFELD. 1946. X-ray induced depolymerization of thymonucleohistone and of sodium thymonucleate. *Science*, 104: 245–6.

SPEAR, F. G. 1944. The action of neutrons on bacteria. *Brit. J. Radiol.*, 17: 348–351.

——. 1946. The biological effects of penetrating radiation. A review. *Brit. med. Bull.*, 4: 2–10

SPERTI, G. S., J. R. LOOFBOUROW, and C. M. DWYER 1937. Proliferation-promoting factors from ultraviolet injured cells. *Inst. Divi. Thomae*, 1: 163–191.

——, ——, and M. M. LANE. 1937. Effects on tissue cultures of intercellular hormones from injured cells. *Science*, 86: 611.

STADLER, L. J., and F. M. UBER. 1942. Genetic effects of ultraviolet radiations in maize. IV. Comparison of monochromatic radiations. *Genetics* 27: 84–118.

STEVENS, N. M. 1909. The effects of ultraviolet light upon the developing eggs of *Ascaris megalocephala*. *Arch. Entwmech. Org.*, 27: 622–639.

STONE, R. S. 1946. Health protection activities of the Plutonium Project. A symposium on atomic energy and its implications. *Proc. Amer. Phil. Soc.*, 90: 11–20.

STRANGEWAYS, T. S. P., and F. L. HOPWOOD. 1926. The effect of x-rays upon mitotic cell division in tissue cultures in vitro. *Proc. Roy. Soc.*, B, 100: 283–293.

SUMMERS, F. M., and H. K. HUGHES. 1940. Experiments with *Colpidium campylum* in high frequency electric and magnetic fields. *Physiol. Zool.*, 13: 227–242.

SVEDBERG, T., and S. BROHULT. 1939. Splitting of protein molecules by ultraviolet light and alpha rays. *Nature* (*Lond.*), 143: 938–939.

SWANSON, C. P. 1943. Differential sensitivity of prophase pollen tube chromosomes to x-rays and ultraviolet radiations. *J. gen. Physiol.*, 26: 485–494.

——, and A. HOLLAENDER. 1946. The frequency of x-ray induced chromatid breaks in *Tradescantia* as modified by near infra red radiation. *Proc. Natl. Acad. Sci. Wash.*, 32: 295–302.

TAYLOR, B., J. P. GREENSTEIN, and A. HOLLAENDER. 1947. Effects of x-radiation on thymus nucleic acid. *Science*, 105: 263–264.

TAYLOR, C. V., J. O. THOMAS, and M. G. BROWN. 1933. Studies on protozoa. IV. Lethal effects of the x-radiation of a sterile culture medium for *Colpidium campylum*. *Physiol. Zool.*, 6: 467–492.

TENNENT, D. H. 1938. Some problems in the study of photosensitization. *Amer. Nat.*, 72: 97–109.

——. 1942. The photodynamic action of dyes on the eggs of the sea urchin, *Lytechinus variegatus*. *Carnegie Inst. Wash. Publ.*, 529. *Papers Tortugas Lab.*, 35: 1–153.

THOMES, J. R. 1946. Radiation sickness in Nagasaki. *U. S. naval med. Bull.*, 46: 219–224.

TIMOFEEF-RESSOVSKY, N. W., and K. G. ZIMMER. 1938. Neutronbestrahlungsversuche zur Mutationsauslösung an *Drosophila melanogaster*. *Naturwiss.*, 26: 362–365.

VINTEMBERGER, P. 1928. Sur les variations de la radiosensibilite zu cours des premieres mitoses de segmentation dan l'oeuf de *Rana fusca*. *C. r. Soc. Biol., Paris*, 98: 532–535; 536–537.

WARREN, S. L. 1928. The physiological effects of roentgen radiation upon normal body tissues. *Physiol. Rev.*, 8: 92–129.

WEBB, A. M., and J. R. LOOFBOUROW. 1947. Intercellular hormones. 6. Release and synthesis of factors of the vitamin B complex by damaged living cells. *Biochem. J.*, 41: 114–119.

WEISS, J. 1941. The photochemical primary process of ions in aqueous solutions. *Trans. Faraday Soc.* 37: 463–469.

——. 1944. Radiochemistry of aqueous solutions *Nature* (*Lond.*), 153: 748–750.

——. 1946. Biological action of radiations. *Nature* (*Lond.*), 157: 584.

WENK, P. 1939. Zur Frage der Punkterwärmung in hochfrequenten Wechselfeld. *Strahlentherapie*, 65: 657–663.

WHITING, A. R. 1940. Sensitivity to x-rays of different meiotic stages in the unlaid egg of *Habrobracon*. *J. exp. Zool.*, 83: 249–269.

——. 1946. Motherless males from irradiated eggs. *Science*, 103: 219–220.

WHITNEY, W. R., and A. B. PAGE. 1935. Short radio waves and fever therapy. *Arch. phys. Ther. X-ray, Rad.*, 16: 477–480.

WILBUR, K. M., and R. O. RECKNAGEL. 1943. The radiosensitivity of eggs of *Arbacia punctulata* in various salt solutions. *Biol. Bull.*, 85: 193–200.

WITKIN, E. M. 1946. Inherited differences in sensitivity of radiation in *Escherischia coli*. *Proc. Natl. Acad. Sci. Wash.*, 32: 59–68.

WYCKOFF, R. W. G. 1930a. The effect of cathode rays upon certain bacteria. *J. exp. Med.*, 51: 921–932.

——. 1930b. The killing of colon bacilli by x-rays of different wavelengths. *J. exp. Med.*, 52: 769–780.

ZIRKLE, R. E. 1936. Modification of radiosensitivity by means of readily penetrating acids and bases. *Amer. J. Roent.*, 35: 230–237.

——. 1940. Influence of intracellular acidity in the radiosensitivity of various organisms. *J. cell. comp. Physiol.*, 16: 301–311.

——. 1941. Combined influence of x-ray intensity and intracellular acidity on radiosensitivity. *J. cell. comp. Physiol.*, 17: 65–70.

——, and P. C. ABERSOLD. 1936. Relative effectiveness of x-rays and fast neutrons in retarding growth. *Proc. Natl. Acad. Sci. Wash.*, 22: 134–138.

LIFE TABLES FOR NATURAL POPULATIONS OF ANIMALS

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At sperat adulescens diu se victurum, quod sperare idem senex non potest. Insipienter sperat; quid enim stultius quam incerta pro certis habere, falsa pro veris?

—Cicero, *De Senectute*

INTRODUCTION

"THE certainty of death", remarks Sir Thomas Browne, "is attended with uncertainties, in time, manner, places." The same refrain, audible in classical authors from Horace to Hoffenstein, embodies immutable truth. But the rise of life insurance has taught us to ask the fatal question differently. We now substitute "probability" for "certainty," and have exchanged our fates for parameters of populations. The dictum of Galilei, "to measure what can be measured, to make measurable what can not be measured," has been applied to the product of Lachesis' loom, with interesting results.

There is no evidence that man's maximum life span has been lengthened a particle since antiquity. The celebrated cases of fantastic longevity, from Methuselah to Thomas Parr, do not withstand critical scrutiny. The mean length of life, however, differs widely among the races of men, is notably lower for most primitives than for civilized populations, and has been increasing by leaps and bounds in the United States during the last century. In ancient Rome, according to Macdonell's analysis (1913), the expectation of life at age 10 was an additional 22 years, compared to an additional 55 years for a male resident of the United States in 1929–31 (Dublin and Lotka, 1935).

The Romans, in fact, knew more about such matters than might be supposed from their superstition that "ten times twelve solar years were the term fixed for the life of man, beyond which the gods themselves had no power to prolong it; that the fates had narrowed the span to thrice thirty years, and that fortune abridged even this period by a variety of chances, against which the protection of the gods was implored" (Hodge, 1857, cited from Niebuhr's *History of Rome*). A table showing the expection of life at birth, at age 20, and at 5-year intervals thereafter, evidently based on real experience and intended for the computation of annuities, was in use in the third century A.D.; it is attributed to Ulpian (Trenerry, 1926). Even the Babylonians seem to have known about insurance contracts, though this does not necessarily imply any actuarial knowledge, and Horace's reference to "Babylonian numbers"—"Tu ne quaesieris (scire nefas) quem mihi, quem tibi finem di dederint, Leuconoe, nec Babylonios temptaris numeros" (*Odes*, I: 11)—may mean more than he intended.

Having gained some idea of the limits circumscribing his own mortality, man has turned to look at the other animals. In 1935 Pearl and Miner, in their discussion of the comparative mortality of lower organisms, attempted to formulate a general theory of mortality. They quickly gave up the attempt upon realizing that the *environmental* determinants of life duration can not, at least as yet, be disentangled from such *biological* determinants as genetic constitution and rate of living. They ended with a plea for "more observational data, carefully and critically collected for different species of animals and plants, that will follow through the life history from birth to death of each individual in a cohort of statistically respectable magnitude." Thus by implication Pearl and Miner appealed to the ecologists, who for the most part have been busy elsewhere. Accounts of the conceptions and methodology of life tables have not yet found their way into textbooks of ecology, and while field naturalists have devoted increasing attention to the dynamics of natural populations

most of them have been content to leave the construction of life tables to the statisticians and laboratory ecologists.

This article, which is designed as an introduction to the subject rather than as a formal review, brings together from the ecological literature a mass of information bearing on the survival of animals in nature. This information has not heretofore been considered relevant by biometricians working with human populations, nor has it ever been considered in its context by ecologists. In collecting the material it was immediately obvious that it is still too early to formulate general theories. Serious deficiencies are only too apparent in the data. But the difficulties differ from case to case, and are therefore not insurmountable. Moreover, the bibliography will show that virtually all of this knowledge has been acquired in the twelve years since the appearance of the review by Pearl and Miner. By taking stock now, and by calling attention to gaps in our information, it is hoped that some guidance can be given to ecologists and others in the gathering of new material.

THE MEANING OF THE LIFE TABLE

A life table is a concise summary of certain vital statistics of a population. Beginning with a cohort, real or imaginary, whose members start life together, the life table states for every interval of age the number of deaths, the survivors remaining, the rate of mortality, and the expectation of further life. These columns are symbolized by d_x, l_x, q_x and e_x, respectively, where x stands for age. Additional columns which may be tabled include the age structure (L_x) or the number of persons living who are between ages x and $x + 1$.

Because all the life table functions can be calculated from each other, it makes little difference where one begins in summarizing the method of construction. It is convenient to begin with deaths at given ages (d_x), since these usually make up the "raw data." A curve obtained by plotting number of deaths against age is obviously a histogram showing the frequency distribution of deaths. It is customary to reduce the data to a relative basis by expressing the observed number of deaths at any age as a fraction of the total number of deaths. Such fractions stated as percentages and carried out to three figures include a decimal place; in this review and elsewhere where small samples are involved, it is the practice to drop the decimal point and put deaths, etc., on a "per thousand" basis. Starting, then, with a cohort of 1000 individuals born together, survivorship (l_x) is obtained by successive subtraction of deaths in the age interval from survivors at the beginning of the age interval. Mortality rate (q_x) is the fraction of those living at the beginning of the age interval who die during the interval, $q_x = d_x/l_x$, and is usually expressed here on a per thousand basis, $1000\ q_x = 1000\ d_x/l_x$.

The calculation of expectation of life is more complicated. For individuals at age 0 (at the beginning of their life span), it is the same as the mean length of life of the cohort. For older individuals, it is the mean life span remaining to those attaining a given age. It could therefore be calculated for any age x by measuring the area under the survivorship curve beyond x and dividing by the number of survivors attaining age x,

$$e_x = \frac{\int_x^\infty l_x \cdot dx}{l_x}$$

However, a life table, among other things, is a device for obtaining such integrals arithmetically, being divided into age intervals so small that changes between age x and $x + 1$ can be regarded as linear functions of x. It is therefore assumed that the *age structure*, L_x, or the number of persons alive who are between ages x and $x + 1$, which is exactly given by

$$L_x = \int_x^{x+1} l_x \cdot dx$$

is in practice given by

$$L_x = \frac{l_x + l_{x+1}}{2}$$

Successive values of L_x obtained in this way are then summed from the bottom of the column up to each age x. This gives T_x, the total number of (persons × age units), or person-years if age is expressed in years still to be lived by persons of age x. Dividing by l_x, the number of persons, gives the expectation of life in age units,

$$e_x = \frac{T_x}{l_x}$$

Farner (1945) calculates e_x directly for each year of a bird's age by obtaining the mean after lifetime

of birds alive on their first November 1, doing the same for birds alive on their second November 1, and so on. This procedure is cumbersome, and is more accurate than the method given here only if the deaths in any year are so unequally distributed through the year that a serious error results from ignoring the fact (Lack, 1943b).

Nice (1937) gives, as Table XXVIII, the "theory as to age composition of a population of breeding birds; theoretical numbers of each age according to annual survival rate." As this table has been frequently used by students of bird populations, it is as well to understand its construction. Actually, it consists of a group of life table d_x columns, constructed on the assumption of mortality rates the number of deaths. For the ratio of the living at any age to the total number living must equal the ratio of the dead at any age to the total number of deaths,

$$\frac{l_x}{\Sigma l_x} = \frac{d_x}{\Sigma d_x}.$$

But $\Sigma d_x = 100$, by convention; therefore

$$100\,\frac{l_x}{\Sigma l_x} = d_x.$$

By the same reasoning it can be shown that

$$100\,\frac{L_x}{\Sigma L_x} = dx.$$

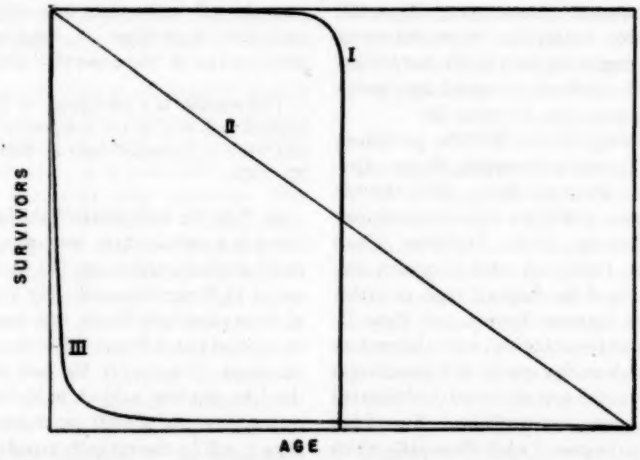

FIG. 1. SCHEMATIC REPRESENTATION OF THEORETICAL TYPES OF SURVIVORSHIP CURVE, ADAPTED FROM PEARL AND MINER (1935)

The survival axis can be graduated either arithmetically or logarithmically, but the logarithmic scale is more instructive, in that a straight line implies equal *rates* of mortality with respect to age.

which are *constant with respect to age*, but change from column to column between 75 and 25 per cent per year. It may seem surprising that a table of deaths should show the age composition of the living, but this is merely a consequence of starting with a round number of births, 100 in this case. Nice takes a cohort of 100 individuals and obtains their survivorship by successive applications of the assumed mortality rate until the number of survivors is reduced to 1. She then expresses the number living at any age as a percentage of the total number living at all ages, and thus the age composition of the living becomes identical with Nice's table is convenient for ornithologists, since the assumption of constant age-specific mortality rates proves to be approximately true for adult birds. When mortality rates change with age, as they normally do, the table is inapplicable, though of course the age composition computed as percentage will always bear the same relationship to the d_x column. Nice states that her table applies to species breeding at one year of age, but this is not a necessary condition, as Farner (1945) has pointed out: it merely implies that the birth rate cannot be deduced from the life table age composition unless all members of the population breed every year.

The fact that the various life table columns are interconvertible makes it unnecessary to discuss all of them in dealing with a given species. Usually it is sufficient to focus attention on the survivorship curve, since this is most readily comprehensible. Pearl and Miner (1935; see also Pearl, 1940) have made it clear that there are three possible sorts of distribution of survivorship with respect to age, as shown diagrammatically in Fig. 1. Type I, the *negatively skew rectangular*, is shown by members of a cohort which, having been born at the same time, die more or less simultaneously after a life span which is presumably characteristic of the species. Type II is *diagonal* (when the logarithm of the number of survivors is plotted against age), implying a constant mortality rate for all age groups, or no one age as a favored time of dying. Type III, the *positively skew rectangular*, shows extremely heavy mortality beginning early in life, but the few individuals which survive to advanced ages have a relatively high expectation of further life.

Most survivorship curves hitherto published, including those for man, *Drosophila*, *Hydra*, *Agriolimax*, the mouse (Pearl and Miner, 1935), the vole (Leslie and Ranson, 1940), the black widow spider (Deevey and Deevey, 1945), *Tribolium* (Pearl Park, and Miner, 1941), and other laboratory animals, are variants of the diagonal type, or rather are intermediate between Type I and Type II. Type III has never been obtained with a laboratory population, though marine species with pelagic eggs and larvae, such as the oysters, would doubtless fall here if complete data were available. Type I has been observed in the case of adult *Drosophila* which were given no food, but this sort of survivorship is probably to be thought of as a laboratory curiosity.

KINDS OF LIFE TABLES

Life tables for human populations, which differ in certain important respects from animal populations in nature, are calculated by roundabout methods, most of which have little relevance to ecology. Some understanding of them is nonetheless essential. Census data show the number of persons born in a given year living in various political areas. Published vital statistics give the number of deaths in the same areas each year and the ages of those dying. By combining the two sets of figures it is possible to arrive at estimates of the rate of mortality (q_x) suffered by persons of a given age *at the time of the census*. Using a smooth curve fitted with exquisite precision to the q_x data, a life table can be constructed on the assumptions: (1) that a standard cohort (100,000 persons) is born alive uniformly throughout the year of the census; (2) that its members will be exposed throughout life to these particular mortality rates; and (3) that there is no immigration or emigration.

A life table so derived exposes to view a purely theoretical population, one which might have existed at the time of the census, but which ceased to exist even before the census was complete. For human populations are notably subject to immigration and emigration; the best known ones are growing, and their age structure is therefore changing; and what is even more important, the mortality rates observed at the time of the census are certain to change with the passage of time. An example will make clear how ordinary life table procedure crystallizes an imaginary population from a series of "time-specific" death rates.

This example is a paraphrase of Merrell's lucid exposition delivered at the symposium on "Life Tables and Their Application" held at Boston on December 27, 1946.

In 1940 the individuals, born in 1890 and now living in a certain state, were exposed to a risk of death at their current age (50 years) which works out at 12.58 per thousand. By 1950 the survivors of these same individuals, now aged 60 years, will be exposed to a different risk of death, say 27.03 per thousand. Eventually the last survivor will be dead, having been subject, in his last year of life, to a mortality rate of 1000 per thousand, and at that time it will be theoretically possible to construct a survivorship curve for the original group of individuals born in the state in 1890 and suffering age-specific mortality rates which changed systematically throughout their lives. But this will be impossible to do in practice, since (1) the birth records for 1890 are incomplete, and (2) many of those whose births were recorded will have left the state and died elsewhere. Moreover, (3) they will have been replaced by a number (probably a larger number) of persons born elsewhere in 1890, subjected to different mortality risks for varying fractions of their lives, who appear in the death records merely as "born in 1890."

In 1940, however, we also know the mortality rate for individuals born in 1900, and now 40 years of age. By 1950, when these persons are 50 years old, their age-specific mortality rate at age 50 will be obtainable. It will not be 12.58 per thousand,

but probably a slightly lower figure. In fact, the mortality rates for all ages will have changed slightly, some more, some less, by 1950, partly because of immigration and emigration and partly because of improvements in public health technique. The same applies, mutatis mutandis, to 1960, when the 1900 year-class are 60 years old. In actuarial practice *this does not matter*. By drawing a vertical line, as it were, through all the age-classes present in 1940, and taking their age-specific mortality rates as the basis of a life table, the actuary seizes the only way out of a troublesome situation. He erects a hypothetical population and tables its survivorship, its mortality rates, its age structure, and the expectation of life of its members, and his figures serve for ordinary purposes. In any case they are the best available until the next census, when they have to be completely revised.

A very different life table would result if, instead of arbitrarily halting the flow of events at some particular time, as 1940, we followed all the individuals born in a certain state in a particular year, and recorded their deaths as they occurred. This would be a "horizontal" life table. Human biologists are less interested in this type, for from their standpoint, life being long and patience short, it is more worth while to be able to predict the future than to describe the past. The life table for persons born in 1840 is not of pressing concern to medical scientists (or to insurance salesmen) in 1940, conditions having meanwhile changed profoundly. The two sorts of life table approach identity as the age structure of the population approaches stability in a uniform environment, but these considerations have no real meaning to the actuary, who deals with expanding populations in which births exceed deaths and which are constantly improving their own environmental conditions. The ecologist, on the other hand, is bound to be interested in both kinds of life table. If there is no change in the environment from year to year, and if the natural population is at equilibrium, with recruitment of each age class always kept exactly balanced by deaths, a horizontal life table for the year-class born in 1940 or any other year will be identical with a vertical life table drawn up for all year-classes present in 1940 or any other year. But normally there will be good years and bad years, both the birth rate and the age-specific death rates will oscillate more or less reciprocally, and the resulting differences in the two sorts of life tables will be large.

Since the data necessary for a vertical life table include both a census of the age distribution of the living members of the population and a record of the deaths by ages, the horizontal life table is easier to construct. The experimental ecologist, in particular, can go at the problem directly, by allowing a large cohort to be born at the same time, keeping its members under observation throughout their lives, and recording deaths as they occur. Thus survivorship (l_x) and deaths (d_x) make up the raw data of his experiment. Mortality rates are then easily obtained as the ratio of the dying to the living at any age, and other life table functions follow just as readily. The environment having been maintained constant artificially, there should be no difference between such a life table and one built up vertically from a census made when the age structure becomes stable.

ECOLOGICAL LIFE TABLES

The field ecologist deals with populations which are by no means so elementary as those inside *Drosophila* bottles. Even the total size of the population of a species cannot be easily ascertained for an area large enough to be representative, and calculations of the birth rate and death rate are uncertain at best, largely owing to immigration and emigration. It is seldom indeed that the ecologist knows anything of the age structure of a natural population. In a few cases, growth rings on the scales or otoliths (fish) or horns (ungulates) make it possible to determine the age of an animal. Moore (1935) has shown that annual growth rings occur in the genital plates of sea-urchin tests, as they do in the shells of some molluscs. Moore checked the validity of the age determination by reference to the size-frequency distribution in his catches, and the separation of modal size classes in a population often affords a clue to age, particularly for younger age groups. The age of adult females can be determined in the case of certain mammals (whales, Wheeler, 1934, Laurie, 1937; seals, Bertram, 1940) by counting the corpora lutea in the ovaries. But for most animals it is possible to find out the ages of individuals only by marking them in some way.

Even when the age of a member of a natural population is known, it is not a simple matter to obtain accurate vital statistics. The source of greatest confusion lies in the impracticability of

keeping the individuals under continuous observation. Migratory birds, for example, are easy to band as nestlings, but nearly impossible to find between fledging and the time they leave for winter quarters. Often they can not be found at all unless they return to the same area to breed, when they can be trapped in nest boxes. Their mortality between fledging and breeding can be calculated, but the calculation is rendered uncertain by the tendency of young birds not to return to their birthplaces as breeding adults.

As sources of data for the construction of life tables, the ecological information falls into three groups: (1) cases where the age at death (d_x) is directly observed for a large and reasonably random sample of the population; (2) cases where the survival (l_x) of a large cohort (born more or less simultaneously) is followed at fairly close intervals throughout its existence; (3) cases where the age structure is obtained from a sample, assumed to be a random sample of the population, and d_x is inferred from the shrinkage between successive age classes. It should be noticed that only the second sort of information is statistically respectable, since in so far as the breeding can safely be assumed to be simultaneous, it is comparable to that obtained from a *Drosophila* bottle. The first and third types can be used only if one is prepared to assume that the population is stable in time, so that the actual age distribution and the life table age distribution are identical. This assumption would certainly not be true of a human population; it may be approximately true for many natural populations of animals. When it is definitely not true, e.g., when certain age classes are stronger or weaker than they should be, to take the ages at death or the actual age structure as observed at any "instant" of time will give erroneous estimates of the age-specific mortality rates. In these cases it would be better to construct a series of horizontal life tables, one for each year class. A vertical life table could be constructed from the average age composition observed over many years, if the ages at death were also known. But the ecological information does not yet give both the census by ages and the deaths by ages for any one population.

In making comparisons between species that have widely different life spans, Pearl's device is very useful. This consists in shifting the origin of the age axis from zero to the mean length of life and regraduating the age scale so that age is expressed as percentage deviation from the mean. In this way l_x values (and other life table functions, should they be desired) can be shown on the same graph in equal detail for rotifers, which live for a matter of days, and for birds, which live for many years. In connection with this method it has been customary to work with a fitted curve, the life table functions being calculated for equal percentage deviations, as -80%, -60%, -40%, etc. This procedure, applied to the natural populations considered in this review, would entail an enormous amount of arithmetical labor which does not seem to be justified by the end in view. Curve fitting minimizes observational error and generalizes the sweep of the observations, but in this case the generalization goes too far, in that it seems to confer a universality on the resulting life table which is not supported by the facts. The published life tables for *Drosophila*, the flour beetle, and other lower organisms apply only to the particular experimental conditions under which they were obtained. Under other conditions, e.g., with different population densities, the longevity will be different and different life tables will result. Accordingly, all life tables presented below have been treated simply, and age intervals, though expressed as percentage deviation from the mean longevity, have been entered in the tables only for values corresponding to the original observations. The only exception is the life table for *Balanus balanoides* (see footnote, Table 6).

Age at Death Directly Observed

In the course of his careful investigation of the wolves of Mt. McKinley, Murie (1944) picked up the skulls of 608 Dall mountain sheep (*Ovis d. dalli*) which had died at some time previous to his visit, and an additional 221 skulls of sheep deceased during the four years he spent in the Park. The age of these sheep at death was determinable from the annual rings on the horns. "Time, which antiquates antiquities, and hath an art to make dust of all things, hath yet spared these minor monuments" (Sir Thomas Browne, *Urn Burial*). Most of the deaths presumably occurred directly as a result of predation by wolves. Many skulls showed evidence of a necrotic bone disease, but it is not possible to say whether death was due solely to the disease or whether the disease merely ensured death by predation.

The mean longevity of the later sample is significantly greater (7.83 years) than that of the earlier (7.09 years), but the interpretation of this fact is

not clear. The form of the distribution of deaths is sensibly the same in the two samples. As the survival of the members of this population is astonishingly great, it seems best to be conservative, and attention has been focussed on the larger, earlier sample. Except for the "lamb" and "yearling" classes, which are doubtless under-represented in the data owing to the perishability of their skulls, there is no reason to suppose that either group is anything but a fair sample of the total population, i.e., the probability of finding a skull is not likely to be affected by the age of its owner. A life table for the 608 sheep has accordingly been prepared (Table 1). The survivorship curve, plotted logarithmically in Fig. 2, is remarkably "human" in showing two periods of relatively heavy mortality, very early and very late, with high and nearly constant survival ratios at intermediate ages.

The adult sheep have two principal methods of defense against wolves, their chief enemies: flight to higher elevations, where wolves can not pursue; and group action or herding. It is clear that these recourses confer a relative immunity to death by predation and that only the very young, which have not learned by experience, and the very old, which are too feeble to escape, suffer heavy losses. This survivorship curve is decidedly not of the positively skew rectangular type.

The second case to be discussed is that of an aquatic invertebrate, the sessile rotifer *Floscularia conifera*. This species has been studied by Edmondson (1945) under conditions which are fully as natural as those enjoyed by Murie's mountain sheep. *Floscularia* lives attached to water plants, especially *Utricularia*, surrounded by a tube constructed by itself out of pellets of detritus. The tube is added to at the top continuously throughout life, and Edmondson was able to identify all the members of a population living in a pond by dusting the *Utricularia* plant with a suspension of powdered carmine. On subsequent visits the *Floscularia* present at the time of dusting were conspicuously marked by bands of carmine-stained pellets in the walls of their tubes, each band being surmounted by new construction of varying widths. Thus in one operation the stage was set for an analysis of growth, age, birth-plus-immigration,

TABLE 1

Life table for the Dall Mountain Sheep (Ovis d. dalli) based on the known age at death of 608 sheep dying before 1937 (both sexes combined). Mean length of life 7.09 years*
Data from Murie (1944)

x	x'	d_x	l_x	$1000\ q_x$	e_x
AGE (*years*)	AGE AS % DEVIATION FROM MEAN LENGTH OF LIFE	NUMBER DYING IN AGE INTERVAL OUT OF 1000 BORN	NUMBER SURVIVING AT BEGINNING OF AGE INTERVAL OUT OF 1000 BORN	MORTALITY RATE PER THOUSAND ALIVE AT BEGINNING OF AGE INTERVAL	EXPECTATION OF LIFE, OR MEAN LIFE-TIME REMAINING TO THOSE ATTAINING AGE INTERVAL (*years*)
0–0.5	−100	54	1000	54.0	7.06
0.5–1	−93.0	145	946	153.0	—
1–2	−85.9	12	801	15.0	7.7
2–3	−71.8	13	789	16.5	6.8
3–4	−57.7	12	776	15.5	5.9
4–5	−43.5	30	764	39.3	5.0
5–6	−29.5	46	734	62.6	4.2
6–7	−15.4	48	688	69.9	3.4
7–8	−1.1	69	640	108.0	2.6
8–9	+13.0	132	571	231.0	1.9
9–10	+27.0	187	439	426.0	1.3
10–11	+41.0	156	252	619.0	0.9
11–12	+55.0	90	96	937.0	0.6
12–13	+69.0	3	6	500.0	1.2
13–14	+84.0	3	3	1000	0.7

* A small number of skulls without horns, but judged by their osteology to belong to sheep nine years old or older, have been apportioned *pro rata* among the older age classes.

and death in a natural population. Among other spectacular results, Edmondson found that the expectation of life of solitary individuals was only half as great as that of members of colonies of two or more, and he presented separate life tables for each component of the population, calculated from the age at death. To facilitate comparison with other species, however, solitary and colonial individuals have been lumped together (for Edmondson's "Experiment 1") in the life table of Table 2.

The survivorship curve (Fig. 2), like that of the Dall sheep, shows unexpectedly good survival. As Edmondson has pointed out, it is not so good as that of other rotifers reared in the laboratory under standard conditions (*Proales decipiens*, *P. sordida*, *Lecane inermis*), but it is only a little less good, and life tables for these rotifers are notorious (Pearl and Miner, 1935) for their close approach to a Type I distribution.

The case of *Floscularia* is almost above reproach as an example of a life table obtained under natural conditions. It is, of course, open to the objection that only the age at death is known, and the age structure of the living animals must be assumed to be constant. Apart from this deficiency, it should also be realized that the origin of the life table is not at birth. The pelagic larval life of the rotifer, like the larval life of barnacles and insects, is omitted from consideration in such a table.

A life table for a population of herring gulls (*Larus argentatus*) has recently been prepared by Paynter (*in press*). These gulls, banded as chicks at the Bowdoin Scientific Station, Kent Island, Bay of Fundy, have been recovered dead from all over North America. No special effort was made to recover banded gulls at their birthplace, and the colony is a large one (ca. 30,000 birds). The fact remains, however, that the first-year birds are perhaps more likely to be picked up than older birds near the place of banding, and perhaps less likely to be picked up elsewhere, so that some doubt can be cast on the reliability of the first-year recoveries as truly representative of the deaths in the first year. This troublesome point is probably less serious than with the songbirds to be discussed below; moreover, it is overshadowed by another difficulty, the fact that the study is not complete, and many of the banded birds are still alive. Paynter minimized this error by a compensatory adjustment; since banding began ten years ago and is still being carried out, first-year recoveries were divided by 10, second-year recoveries by 9, etc. Birds dying at ages greater than 10 years have naturally not yet been recorded, though a few are to be expected.

That these older birds will probably not change the life table appreciably is shown by Marshall's independent study (1947) of the longevity of the herring gull. Marshall used all available records of American herring gulls banded as young during

TABLE 2

Life table for the sessile rotifer Floscularia conifera based on the known age at death of 50 rotifers, both solitary and colonial. Mean length of life 4.74 days
From Edmondson (1945), Experiment 1

x	x'	d_x	l_x	$1000\,q_x$	e_x
AGE (*days*)	AGE AS % DEVIATION FROM MEAN LENGTH OF LIFE	NUMBER DYING IN AGE INTERVAL OUT OF 1000 ATTACHING	NUMBER SURVIVING AT BEGINNING OF AGE INTERVAL OUT OF 1000 ATTACHING	MORTALITY RATE PER THOUSAND ALIVE AT BEGINNING OF AGE INTERVAL	EXPECTATION OF LIFE, OR MEAN LIFE TIME REMAINING TO THOSE ATTAINING AGE INTERVAL (*days*)
0–1	−100	20	1000	20	4.76
1–2	−78.9	200	980	204	3.78
2–3	−57.8	60	780	77	3.70
3–4	−36.7	0	720	0	2.98
4–5	−15.6	300	720	416	1.97
5–6	+5.4	140	420	333	2.02
6–7	+26.7	60	280	214	1.79
7–8	+47.7	140	220	636	1.14
8–9	+68.8	40	80	500	1.25
9–10	+90.0	20	40	500	1.00
10–11	+111.0	20	20	1000	0.50

the last 25 years and subsequently recovered dead. Thus his data probably include most of the returns from the Kent Island population. Returns before September 1 of the first year of life were excluded, so that the life table refers to adult birds only. It differs from Paynter's chiefly in that it includes birds older than 10 years, one bird having lived as long as 17 years. Despite two factors which might be supposed to enhance the apparent longevity (exclusion of juvenile mortality; inclusion of older birds) the expectation of life is markedly lower than that of the Kent Island colony, 1.5 years on the first September 1 of life as against 2.44 years at banding age.

Probably neither set of data for the herring gull is wholly reliable. Paynter's calculations suggest that the Kent Island population is just replacing its losses, assuming a rather high reproductive potential and a rather low rate of mortality between hatching and fledging, while a similar calculation applied to Marshall's figures implies that the population as a whole must be declining. Several reasons may be suggested for the discrepancy between the two life tables: (1) the mortality of the Kent Island gulls may actually be lower than average; (2) there may have been greater total mortality before 1936, and Marshall's recoveries may have been predominantly from the earlier years, before banding started at Kent Island. The simplest explanation is that (3) an appreciable number of bands are lost by older birds, so that the mean age at death is actually higher than appears from the returns of banded birds.

These questions will doubtless be discussed by Paynter on the basis of direct observation of juvenile mortality, planned for the coming summer (1947) at Kent Island. Meanwhile, taking his life table at face value, the figures have been entered in Table 3, and the survivorship curve is plotted in Fig. 2 for comparison with the Dall sheep and the rotifer. In contrast to those cases, the curve for the gulls is of the diagonal type, the mortality rate being approximately constant throughout life. This feature seems to be characteristic of birds, as will appear below. The causes of death of these birds have been discussed in detail by Paynter, who finds that there is no significant difference in mean length of life between gulls dying through human interference (shooting, trapping, etc.) and those dying through "natural" or unknown causes.

In his delightful book, *The Life of the Robin* (1943a) and in two admirable papers, Lack (1943b,

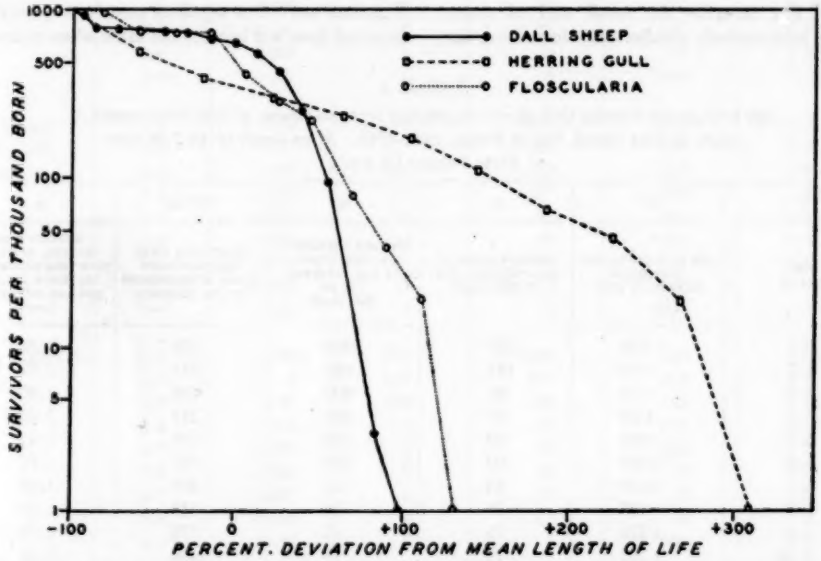

FIG. 2. SURVIVORSHIP (l_x) CURVES FOR THE DALL MOUNTAIN SHEEP, THE SESSILE ROTIFER FLOSCULARIA CONIFERA, AND THE HERRING GULL, AGE BEING EXPRESSED AS PERCENTAGE DEVIATION FROM THE MEAN LENGTH OF LIFE

c) has investigated the age at death of certain British birds, as obtained by recoveries of individuals banded as nestlings. Because banded nestlings are likely to be picked up near the banding stations or not at all, it is impossible to estimate the whole of the mortality in the first year of life with any accuracy, and Lack begins his life tables on August 1. The proportion of birds banded which are later recovered is small, ranging from 1.0 per cent for the robin to 18.4 per cent for the cormorant; but after August 1 of the first year it is considered that the ages at death of birds recovered are not likely to differ from the ages at death among the total population. The samples are small and of course become progressively smaller with increasing age, they suffer more or less severe depredations from shooting.

The striking feature of these survivorship curves is their diagonal form. The mortality in the first year varies from 380 per thousand for the lapwing to 723 per thousand for the robin, but for a given species the mortality remains approximately constant throughout life, or at least for as long as the data are reliable.

When the ages of these birds are transformed into percentage deviations from the mean, as in Fig. 4, it becomes obvious that the mortality per unit of life span is constant for all the birds studied. This does not tell us anything new, for any series of diagonal lines will become the same when replotted

TABLE 3

Life table for the Herring Gull (Larus argentatus) based on returns of 1252 birds banded as chicks at Kent Island, Bay of Fundy, 1936–1945. Mean length of life 2.44 years
From Paynter (in press)

x	x'	d_x	l_x	1000 q_x	e_x
AGE (*years*)	AGE AS % DEVIATION FROM MEAN LENGTH OF LIFE	NUMBER DYING IN AGE INTERVAL OUT OF 1000 BORN	NUMBER SURVIVING AT BEGINNING OF AGE INTERVAL OUT OF 1000 BORN	MORTALITY RATE PER THOUSAND ALIVE AT BEGINNING OF AGE INTERVAL	EXPECTATION OF LIFE, OR MEAN LIFE TIME REMAINING TO THOSE ATTAINING AGE INTERVALS (*years*)
0–1	−100	419	1000	419	2.44
1–2	−59	181	581	312	2.84
2–3	−18	95	400	238	2.90
3–4	+23	65	305	213	2.65
4–5	+64	69	240	288	2.22
5–6	+105	60	171	351	1.92
6–7	+146	45	111	405	1.68
7–8	+187	21	66	318	1.48
8–9	+228	26	45	578	0.93
9–10	+269	19	19	1000	0.53

so that Lack does not regard the mortality rates and expectation of life as reliable beyond the fourth or fifth year.

Several of Lack's life tables are reproduced in Table 4, and the survivorship curves are shown in Fig. 3. Three of the species are familiar British songbirds belonging to the Turdidae, the robin (*Erithacus rubecula melophilus*), the blackbird (*Turdus m. merula*), and the song thrush (*T. e. ericetorum*). The others are the starling (*Sturnus v. vulgaris*) and the lapwing (*Vanellus vanellus*), taxonomically though not ecologically a "shore-bird" (Charadriidae). Lack's remaining species, the woodcock, black-headed gull, lesser black-backed gull, and cormorant, have been omitted, as in this way, but it is helpful none the less. A line fitted by eye to the survivorship points plotted in this figure has a slope corresponding to a mortality of about 320 per thousand per 100 per cent deviation. If the divergence of the points for older ages is ignored as being due to inadequate data, and this line projected, it cuts the age axis at about +560 per cent, implying that if the mortality of birds is really constant throughout life, the oldest bird in a group of 1000 adults should survive about 6.6 times as long as the average bird.

The American robin (*Turdus m. migratorius*), a larger bird than its distant English relative, has been studied by Farner (1945), using U. S. Fish and Wildlife Service data on 855 birds banded as young

TABLE 4

Life tables for several British birds, based on returns from all Britain of birds banded as nestlings and known to be alive on August 1 of their first year. Age reckoned from August 1
From Lack (1943a, b, c)

SPECIES; SIZE OF SAMPLE; MEAN LENGTH OF LIFE AFTER FIRST AUGUST 1	x AGE (*years*)	x' AGE AS % DEVIATION FROM MEAN LENGTH OF LIFE	d_x NUMBER DYING IN AGE INTERVAL OUT OF 1000 ALIVE ON AUGUST 1	l_x NUMBER SURVIVING AT BEGINNING OF AGE INTERVAL OUT OF 1000 ALIVE ON AUGUST 1	$1000\,q_x$ MORTALITY RATE PER THOUSAND ALIVE AT BEGINNING OF AGE INTERVAL	e_x EXPECTATION OF LIFE, OR MEAN LIFE-TIME REMAINING TO THOSE ATTAINING AGE INTERVAL (*years*)
Blackbird (352) 1.58 years	0–1	−100	545	1000	545	1.57
	1–2	−37	170	455	374	1.85
	2–3	+27	142	285	498	1.66
	3–4	+90	57	143	398	1.82
	4–5	+153	34	86	396	1.80
	5–6	+216	20	52	385	1.65
	6–7	+280	17	32	531	1.38
	7–8	+343	9	15	600	1.33
	8–9	+405	0	6	0	1.50
	9–10	+470	6	6	1000	0.50
Song Thrush (374) 1.44 years	0–1	−100	556	1000	556	1.44
	1–2	−31	185	444	417	1.61
	2–3	+39	136	259	525	1.40
	3–4	+108	72	123	585	1.39
	4–5	+178	21	51	411	1.65
	5–6	+245	13	30	433	1.43
	6–7	+316	11	17	647	1.12
	7–8	+385	3	6	500	1.17
	8–9	+455	3	3	1000	0.67
Robin (130) 1.01 years	0–1	−100	723	1000	723	1.03
	1–2	−2	131	277	472	1.41
	2–3	+97	108	146	740	1.23
	3–4	+196	23	38	605	2.29
	4–5	+294	8	15	533	4.0
	5–6	+392	0	15	0	3.0
	6–7	+491	0	15	0	2.0
	7–8	+590	0	15	0	1.0
	8–9	+689	8	7	1000	0.5
Starling (203) 1.49 years	0–1	−100	487	1000	487	1.49
	1–2	−33	261	513	509	1.43
	2–3	+34	113	252	448	1.40
	3–4	+102	89	139	640	1.12
	4–5	+168	25	50	500	1.22
	5–6	+236	20	25	800	0.92
	6–7	+302	0	5	0	1.60
	7–8	+370	5	5	1000	0.60
Lapwing (460) 2.36 years	0–1	−100	380	1000	380	2.37
	1–2	−58	213	620	344	2.51
	2–3	−15	128	407	314	2.56
	3–4	+27	78	279	280	2.50
	4–5	+70	67	201	334	2.28
	5–6	+112	56	134	418	2.17
	6–7	+154	24	78	308	2.37
	7–8	+196	20	54	370	2.20
	8–9	+239	7	34	206	2.20
	9–10	+282	9	27	333	1.63
	10–11	+324	7	18	389	1.17
	11–12	+366	11	11	1000	0.55

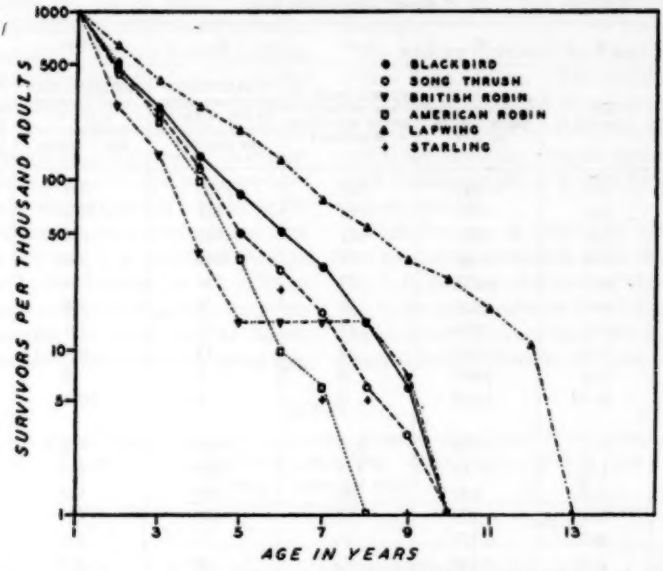

FIG. 3. SURVIVORSHIP (l_x) CURVES FOR THE BRITISH ROBIN, SONG THRUSH, BLACKBIRD, STARLING, LAPWING AND AMERICAN ROBIN, AGE BEING EXPRESSED IN YEARS

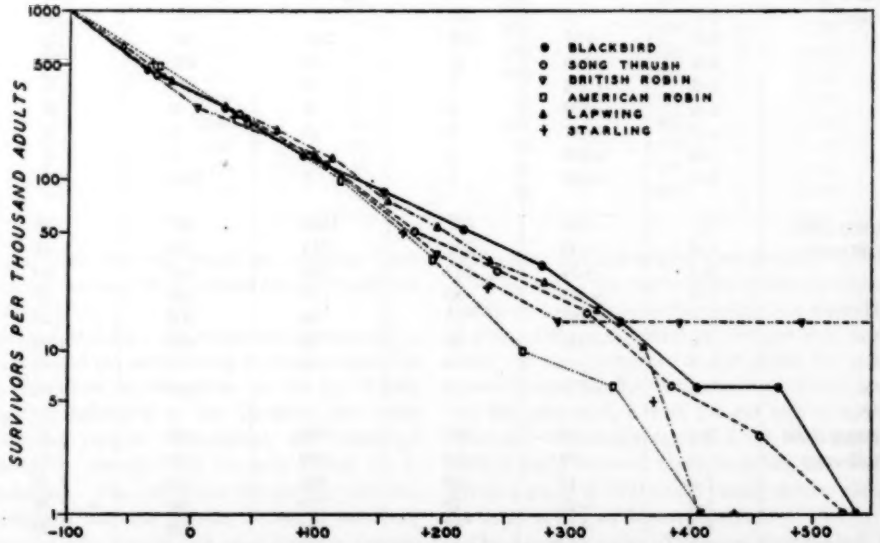

FIG. 4. SURVIVORSHIP (l_x) CURVES FOR THE SAME SPECIES AS IN FIG. 3, AGE BEING EXPRESSED AS PERCENTAGE DEVIATION FROM THE MEAN LENGTH OF LIFE

within the breeding range of the type subspecies between 1920 and 1940, and subsequently recovered dead. Farner's method of treatment of the data is analogous to Lack's, except that November 1 is taken as the starting point for the life table. The figures for the American robin have been entered in Table 5, and Figs. 3 and 4 indicate that this species suffers a mortality which is not only uniform with respect to age but is approximately the same as that of the British birds with respect to units of the mean life span.

Lack (1946) has recently discussed anew the question whether the disproportionately high mortality found among birds in their first year of life is real, or is due to the greater likelihood of their being picked up near the banding station. Analysing the returns between August 1 and January 1 for the blackbird, the song-thrush, the starling, and the lapwing, he found that most of these returns were of first-year birds, but that the proportion of first-year birds is no higher among those found by the bander or found near the banding station than it is among those found at a distance. The annual mortality is greater for first-year birds than for older birds when the calculations begin on August 1, and it remains greater when November 1 is the starting date, but by January 1 the constant level of adult mortality is reached. Calculations of adult mortality should therefore start on January 1, but from a comparative point of view this adjustment is of minor importance. The "disproportionate" mortality in the first year, starting from August 1, is really very little greater than in later years; it is scarcely visible on a logarithmic plot of survivorship (Figs. 3 and 4). The significant differences between juvenile and adult mortality, which would give a marked initial dip on such a plot, have been left out of account altogether, and August 1 is not too early, but too late a starting point.

Additional information on the lapwing is given by Kraak, Rinkel, and Hoogerheide (1940), who studied the age at death of 1333 continental birds banded as juveniles. The life table is not published, but the survivorship curve is reproduced, and is shown to be closely fitted by a line corresponding to a constant mortality rate of 40 per cent per year, reckoned from the first January 1 of life. This value is slightly higher than that found by Lack for the British population, but as the mean length of life is slightly lower, the mortality per unit of life span is the same.

It may be mentioned that the mortality rates for adult song sparrows, dealt with in the next section because the original data give l_x and not d_x, are fully consistent with the picture given by Fig. 4. The same may be said of Paynter's herring gull data, which have been presented separately because juvenile mortality is not specifically excluded, as it is for the other birds. All natural populations of birds so far investigated in any detail appear, therefore, to be alike in suffering a constant annual risk

TABLE 5

Life table for the American Robin (Turdus m. migratorius), based on returns of 568 birds banded as nestlings and known to be alive on November 1 of their first year. Age reckoned from November 1. Mean length of life after November 1—1.37 years

From Farner (1945)

x	x'	d_x	l_x	$1000\,q_x$	e_x
AGE (*years*)	AGE AS % DEVIATION FROM MEAN LENGTH OF LIFE	NUMBER DYING IN AGE INTERVAL OUT OF 1000 ALIVE ON NOVEMBER 1	NUMBER SURVIVING AT BEGINNING OF AGE INTERVAL OUT OF 1000 ALIVE ON NOVEMBER 1	MORTALITY RATE PER THOUSAND ALIVE AT BEGINNING OF AGE INTERVAL	EXPECTATION OF LIFE, OR MEAN LIFE TIME REMAINING TO THOSE ATTAINING AGE INTERVAL (*years*)
0–1	−100	503	1000	503	1.38
1–2	−27	268	497	539	1.26
2–3	+46	130	229	567	1.16
3–4	+119	63	99	636	1.03
4–5	+192	26	36	722	0.94
5–6	+265	4	10	400	1.10
6–7	+338	5	6	1000	0.50

of death from early adult life to the end of the life span, this mortality being constant for birds at about 320 per thousand per hundred centiles of life span. Little is known of the seasonal distribution of these deaths, and it will be very interesting to discover whether non-migratory tropical birds suffer death in similar fashion.

Survivorship Directly Observed

The cases now to be discussed differ from the preceding in the character of the original observations. observations, so that births can be assumed to be simultaneous, as in a *Drosophila* bottle, a horizontal life table can be directly constructed from the survivorship data. Unfortunately, most of the species which have been studied in this way have short spans of natural life, and when census data are obtained only once a year the number of points on the survivorship curve is too small to be satisfactory.

The best example of such observed survivorship comes from Hatton's work (1938) with the barna-

TABLE 6

Life table for a typical population of Balanus balanoides, based on the observed survival of adult barnacles settling on a cleaned rock surface in the spring of 1930. The population is that at Cité, (St. Malo, France), a moderately sheltered location, at Level III, at half-tide level. The initial settling density (2200 per 100 cm²) is taken as the maximum density attained on May 15. Mean length of life 12.1 months

Data from Hatton (1938)

x	x'	d_x	l_x	$1000\,q_x$	e_x
*AGE (*months*)	*AGE AS % DEVIATION FROM MEAN LENGTH OF LIFE	NUMBER DYING IN AGE INTERVAL OF 1000 ATTACHING	NUMBER SURVIVING TO BEGINNING OF AGE INTERVAL OUT OF 1000 ATTACHING	MORTALITY RATE PER THOUSAND ALIVE AT BEGINNING OF AGE INTERVAL	EXPECTATION OF FURTHER LIFE (*months*)
0–2	−100	90	1000	90	12.1
2–4	−83.5	100	910	110	11.3
4–6	−67.0	50	810	62	10.5
6–8	−50.4	60	760	79	9.1
8–10	−33.9	80	700	114	7.8
10–12	−17.4	160	620	258	6.7
12–14	−0.9	80	460	174	6.7
14–16	+16.0	100	380	263	5.9
16–18	+32.2	50	280	179	5.7
18–20	+49.0	40	230	174	4.7
20–22	+65.4	100	190	526	2.4
22–24	+82.0	60	90	667	1.9
24–26	+98.8	20	30	667	1.8
26–28	+115.0	8	10	800	1.4
28–30	+132.0	2	2	1000	1.0

* Survivorship data given graphically by Hatton were smoothed by eye, and values at every other month were then read from the curve. The original observations were made at irregular intervals during three years.

Instead of a fairly large sample of individuals about which little or nothing can be told except their age at death, we have a group of individuals known to have been born at a particular time and to have been present or absent at some later time. Their presence gives their survivorship, their absence implies death in the interval since they were last observed. This is the best sort of information to have, since it does not require the assumption that the age composition of the population is stable in time. Provided only that the season of birth is a small fraction of the age interval between successive

cle, *Balanus balanoides*. This work will be examined in great detail in a later section, and it is here necessary to say only that the case is very nearly ideal. The barnacle settles on rocks during a short time (two to six weeks) in early spring. Test areas were scraped clean one winter, and after new populations had settled, the survival of their members was followed at intervals of one to four months for three years. Barnacles which disappeared from the areas between observations were certainly dead, for emigration does not complicate the problem. Immigration, however, does present

difficulties, though since it is confined to the attachment seasons of subsequent years it should be possible to control it in subsequent work. There is one further disadvantage in that the life tables necessarily start at metamorphosis, leaving out of account mortality during pelagic larval stages. A life table for a typical population of barnacles is presented in Table 6.

The remaining examples suffer from more serious defects, and the data do not justify extended treatment. Green and Evans (1940) in their important study of the snowshoe rabbit (*Lepus americanus*) in Minnesota, followed the survival of marked individuals of several year classes, the total population present on the area and the number in each age-class being obtained by the mark-and-recapture method—also known as the "Lincoln index" (Jackson, 1939). Marking was done during most of the winter, and the annual census was made in February. It is perhaps unnecessary, and certainly uncharitable, to point out two sources of error in this excellent and ingenious work. In the first place, when marked individuals are released into a population and later recaptured, the calculation of the total population from the fraction

$$\frac{\text{size of sample when recapturing}}{\text{number recaptured}} \times \text{number marked}$$

depends on two assumptions, neither of which is likely to be true in this case: that there is no mortality between marking and recapturing; and that the marked individuals disperse at random through the whole population. Secondly, the flow of vital events in this population was so rapid, very few rabbits more than three years old ever having been found, that observations made annually can give only a very rough idea of the life table.

The latter objection applies with equal force to the study of a pheasant population made by Leopold et al. (1943) in Wisconsin. The former objection, though doubtless it could be urged, has less validity here, since the population, as ascertained by trapping, was checked by census drives.

Nice's thoroughgoing work (1937) on the song sparrow (*Melospiza melodia*) included a consideration of the survival of banded birds from year to year. The number of individuals which could be kept under continuous observation was necesarily small, and to find a sample large enough to use as the basis of a life table, it is necessary to take the 144 males banded in the breeding season between 1928 and 1935. Unfortunately, some of these males were of unknown age when first banded. Even if one assumes, (and the assumption is not far from the truth) that all new males appearing are first-year birds born elsewhere, the survival ratios from year to year will be too low if any adult males were still alive but failed to return to the area. Evidently such emigration is of minor importance with adult male song sparrows. With adult females, however, it is so serious that Nice did not think it worth while to publish the data on their return. Clearly, work on the survival of migratory birds is full of uncertainties, though the same may be said of resident species such as the wren-tit (Erickson, 1938) and the robin (Lack, 1943a).

All of these cases, snowshoe rabbit, pheasant, and song sparrow have one defect in common. This is the necessity of calculating the survival between birth and the first year of adult life from other data than those given by banding. For the snowshoe rabbit, the initial strength of the year-class is calculated from the estimated breeding population present and its known fertility. Leopold et al., lacking observations of their own on the pheasant mortality between birth and the first census period, used the estimates given by Errington for pheasants in another state. Nice calculates the survival of fledged young song sparrows to their first breeding season, by assuming a stable population and combining the estimated mean length of life of adults with their average nesting success. These procedures, while perfectly defensible as approaches to the problem, are inadequate substitutes for direct observation.

The three sets of data, with all their uncertainties, have been used as bases for synthetic life tables, and the survivorship curves are presented in Fig. 5. The snowshoe rabbit curve is that for the 1933 year class, the only one for which data are available on rabbits as old as four years. The juvenile mortality for 1933 is calculated by Green and Evans as 77 per cent between birth and the following February; for most other years it was higher, and for a few it was lower. Adult mortality, amounting to 70 per cent per year, was essentially constant throughout the study. The data for the pheasant are the average survival values for adults (30 per cent per year), combined with Errington's estimate of 84 per cent mortality between hatching and maturity. The song sparrow curve is calculated in two ways, the first including only the estimated mortality between fledging and the first breeding season (80 per cent) and the

second also including the loss (40 per cent) between the laying of the eggs and fledging. The adult part of the life span is taken from the survival of the 144 males banded in 1928–1935.

The three curves show a pronounced diagonality from the adult stage onward. Initially, however, since the juvenile mortality in all cases is greater than the adult mortality, the curves show a dip which is most emphatic for the song sparrow reckoned from the egg, but which is invariably present. Here, then, we have for the first time surbetween successive age classes, has not been directly observed. This kind of information lends itself just as well as either of the others to the computation of life tables. As in the group where only the age at death is known, of course, it is necessary to assume the age composition to be unchanged with time. When this assumption is unreasonable, as it often is for fish populations, with their outrageous fluctuation in strength of year-classes, average age compositions obtained from several years' work can often be used. As it happens,

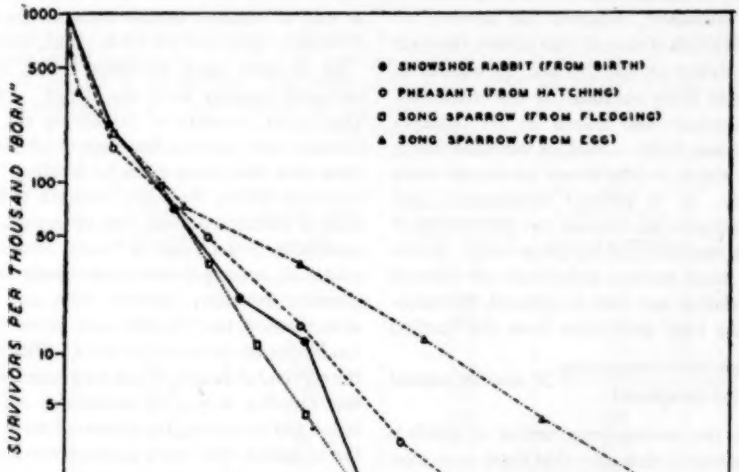

FIG. 5. SYNTHETIC SURVIVORSHIP (l_x) CURVES FOR THE SNOWSHOE RABBIT, THE PHEASANT, AND THE SONG SPARROW, THE LATTER CALCULATED FROM TWO DIFFERENT BIOLOGICAL AGES
Data for different parts of the life spans are derived in different ways, as explained in the text.

vivorship curves which approach the positively skew rectangular type expected in theory from animals in nature. It is surprising that the approach is not closer, but it may well be true that the theoretical curve, in its most extreme form, is not to be looked for among terrestrial vertebrates.

Age Structure Directly Observed

Ecological information of a third sort is available for a number of natural populations, principally of fishes and birds. In these cases the investigator has been able to determine how many individuals of each age are living in the population, and the age at death, though calculable from the shrinkage

however, all the life tables which fall in this third group are incomplete for one reason or another, and the data do not bear close comparison with such examples of natural life tables as those of the Dall sheep and the barnacle.

Kortlandt (1942) has recently given a very elaborate analysis of the Netherlands population of cormorants (*Phalacrocorax carbo sinensis*). Birds banded as nestlings were later observed in their breeding and playing colonies, the numbers on the bands being read with the aid of a telescope. The age distribution of the banded birds being known in 1940 and 1941, it should be possible to infer the age distribution of the total population and from

this to compute the annual mortality suffered by each year-class. A number of complicating conditions are present in this case, however, making direct calculation unreliable and necessitating a more circuitous approach: (1) the size of the Dutch cormorant population is not constant, but has been increasing by about 10 per cent per year, as estimated by counts of nests at the breeding colonies; (2) differences between the observed sex ratio among sexually mature birds and the sex ratio predicted on the basis of estimated mortality by sex and age class show clearly that there is some *band mortality*; that is, some birds either lose bands or die because of the band, making estimates of natural mortality too high by a factor of about 2; (3) it is not possible to infer the complete age structure from observations made at breeding colonies, since the one- and two-year-old birds occupy "colonies" elsewhere, returning to their birthplaces to breed no sooner than their third year.

In view of these difficulties, and others which need not be discussed here, Kortlandt's results must be regarded as schematic and preliminary only, and scarcely warrant the construction of a life table. His computations suggest that cormorants suffer mortality somewhat as follows: 17 per cent between fledging and the first May 1; 8 per cent in the first year; 6 per cent in the second year; and about 4 per cent per year in the third to twelfth years. These are astonishingly low figures for a natural population, but it must be remembered that the population is increasing rapidly. It is interesting to find that the slight differential death rate between the sexes from the third year onward appears to favor the female rather than the male sex. It is not known whether this is true of birds generally, in contrast to most other animals (Geiser, 1923, 1924). MacArthur and Baillie (1932) have maintained that there is no evidence that differential mortality is correlated with the sex-determining chromosome mechanism, and that among moths and birds the male longevity is generally lower in conformity with the "rate of living" theory.

Huge numbers of returns of the common tern (*Sterna hirundo*) have been obtained at the Austin Ornithological Research Station on Cape Cod (Austin, 1942), where terns have been banded for over twenty years. Unfortunately the data are inadequately published, and in any case can yield only an incomplete life table, since terns, like other sea birds, scatter widely after birth and do not return to their birthplace until breeding age. Inspection of Austin's table, in which all returns are given by ages for the four years 1938–1941, suggests that the annual mortality is not constant from the fourth year onward, but varies from 178 to 636 per thousand even between the fourth and eighth years, when the numbers are large. It is not clear, however, whether or not the tern population has remained statistically constant during the period of study, i.e., whether the table really reflects the true natural mortality of an average or of any one year-class.

The literature of fisheries biology is full of attempts to estimate the mortality of fishes, to distinguish natural mortality from rate of exploitation, and to determine the rate of exploitation which, given certain mortality rates and certain relationships between age and size, will steadily yield an optimum catch. These complex questions are fully discussed in the important works of Russell (1942), Thompson and Bell (1934), and Ricker (1940, 1944), and by various authors in the *Rapports et Procès-Verbaux of the International Council for the Study of the Sea*, Volume 110, 1939. Little of this information can be directly used for our purpose. The explanation is as simple as it is regrettable: although the age of a caught fish can be ascertained with more or less complete confidence, fishes of all ages can not be caught with equal facility. Inevitably the methods so skilfully developed for catching fish of desirable sizes will fail to catch fish of undesirable sizes. It is true that on various occasions the whole fish population of a lake has been removed by poisoning or drainage. The estimates given by Eschmeyer (1939) for the abundance of large-mouth black bass (*Huro salmoides*) in Howe Lake, Michigan, at the time of its poisoning in 1937, may be cited as an example:

Age	*Number*
0	18,374
0 (cannibals)	229
I	25
II	10
III	105
IV	7
V and older	9
Total	18,759

The implication of enormously greater mortality in the first year of life is plain from these figures, but such data can not be taken as they stand, partly because of very variable annual recruitment, and partly because young of the year were removed

from the lake at various times for hatchery purposes.

Lacking satisfactory observations of the complete age structure of the population, and faced with the obstacle of variable yearly recruitment in its most massive form, it is not surprising that fisheries workers have not attempted the construction of life tables, and have so far been content with the estimation of natural mortality among fishes of certain sizes only. This mortality is generally assumed to be constant with respect to age, and it may well be so for middle-aged fishes exposed to fishing; but a life table constructed from the available observations would certainly be lacking both head and tail.

As an example of the kind of information yielded by fisheries statistics, and of the methods used in their analysis, we may first take the data given by Ricker (1945) for the bluegill sunfish (*Lepomis macrochirus*) in Muskellunge Lake, Indiana. This is an especially instructive case, for it shows that despite great technical advantages not enjoyed by students of marine fisheries (a small, isolated, self-contained population; size and character of catch known with certainty by the investigator; age structure of the population checked by tagging methods), the difficulties remaining are still embarrassing.

Ricker first determined the rate of exploitation and the total mortality between one year and the next by what he called (rather inappropriately) the "direct" method, involving marked fish. In 1942, of 140 fish 145 mm. and larger (mostly 3 years old and older) marked prior to the opening of the season, 25 were recaptured by fishermen during the season, giving a rate of exploitation of 18 per cent. Estimated autumn fishing raises this figure to 19 per cent. Of 230 blue-gills 125 mm. and larger, marked prior to the 1942 season, 14 were recaptured in 1943. The rate of exploitation of fish in the same size group (then 155 mm. and larger) in 1943 was 15.1 per cent. It is necessary to calculate the number of 1942-marked fish present at the beginning of the 1943 season; this number is given by dividing the number recaptured in 1943 by the rate of exploitation in 1943, or $\frac{14}{0.151} = 93$. These 93 fish were the survivors of 230 marked fish present before the 1942 season, so the rate of mortality from one season to the next was $\frac{230 - 93}{230} =$ 60 per cent. Subtracting the 19 per cent rate of exploitation leaves 41 per cent as the natural mortality.

Ricker's "indirect" method is the life-table method in a crude form. A collection of scales from 529 blue-gills caught by fishermen in 1942 gave the following as the age structure of the sample:

Age.....	I	II	III	IV	V	VI	VII	VIII
Number...	1	293	151	54	20	7	2	1

The age I fish was presumably caught by accident, and those of age II were not equally vulnerable to fishing during the first part of the season. From age III onward the age structure may be used to yield an estimate of the age-specific mortality rates (assuming uniform recruitment and mortality rates from year to year). These mortality rates in early ages, where the data are more reliable, are nearly constant at about 65 per cent. A weighted geometric mean by Jackson's method gives

$$\frac{1 + 2 + 7 + 20 + 54}{2 + 7 + 20 + 54 + 151} = 36\% \text{ survival}$$

$$= 64\% \text{ mortality.}$$

This is close to the 60 per cent mortality calculated by the "direct" method. However, both methods contain unproved and rather unlikely assumptions, and the agreement merely shows the order of magnitude of the total annual mortality. Moreover, the natural mortality as calculated so far is too low, as some of the fish caught by anglers would have died anyway. By making the additional assumption that the natural mortality is synchronized with the fishing mortality, Ricker calculates the former to be of the order of 50 per cent per year for bluegills age III and older in four Indiana lakes. This is an important result, and one which will doubtless surprise many fisheries supervisors. It is not sufficient as the basis for a life table, however, since it does not include the mortality from birth to the third year of life, and since the method of weighting underrates the age-specific mortality at advanced ages. Ricker, in fact, thinks it not unlikely that the older fish are subject to a still higher mortality, but his data give no clear answer to the question.

It is a generally accepted conclusion that *adult* fishes, from the time they enter a fishery to the age at which they cease to be caught in significant numbers, suffer a more or less constant mortality with respect to age. Thus for these intermediate ages the survivorship curves, whether constructed verti-

cally for a series of year-classes in any one fishing season, or horizontally for particular year-classes followed through several seasons, tend to fall on straight lines when plotted logarithmically. Such straight lines, with slopes changing according to the rate of exploitation, are implicit in Raitt's treatment of the statistics on the haddock (1939) and are conspicuous in Jensen's review (1939) of data on the cod, haddock, plaice, and herring in the North Sea. Whether the natural mortality, as distinguished from the fishing mortality, also is constant at all adult ages is an open question, but most fisheries workers would probably be prepared to assume that this is the case, in the absence of evidence to the contrary.

Direct observations of *juvenile* mortality in fishes are not easy to make, but a mass of indirect evidence points to the conclusion that it must be very much greater than adult mortality in many species. Some idea of this mortality can be had from Sette's work (1943) on the mackerel. Eggs and larvae of this pelagic species were caught on several systematically conducted cruises over the continental shelf between Martha's Vineyard and the Chesapeake Capes. Several broods spawned at short intervals during the season of 1932 were recognizable at later times and at geographically remote stations as separate modes in the frequency distributions of size and age. Assuming that the technique of plankton sampling gives a reliable estimate of the abundance of eggs and larvae of particular stages in the sea, their reduction in numbers gives a measure of their mortality. Sette's calculations show that the mortality is very great, and is substantially the same per unit time at all egg and larval stages. There is a noticeable rise in mortality rate, from about 10 to 14 per cent per day up to about 30 to 45 per cent per day, at the transition from larval to post-larval stages, when the fins are developing rapidly, but it falls again to the original level. The total mortality from the beginning of development to the 50 mm. stage, when the baby fish school like the adults and seek out their nursery grounds, is 99.9996 per cent. This fantastically high figure refers to a time interval of about *70 days*, and may be compared with values of 50 to 90 per cent *per year* estimated as the total mortality suffered by several species of commercial fishes as adults. Clearly, Pearl was correct in supposing that the survivorship curve for pelagic fishes may be of the J-shaped or positively skew rectangular form.

Though it can not be doubted that survivorship curves for fishes in nature will in general have an initial dip, it would be incorrect to conclude that this dip is invariably as pronounced as in the case of the mackerel. Barnaby (1944), for example, has considered the mortality of the Karluk River population of red salmon (*Oncorhynchus nerka*). Marking experiments suggest a total mortality in the ocean of about 79 per cent, while a calculation based on the reproductive potential yields a figure for the mortality in fresh water, between birth and seaward migration, of 99.55 per cent. The problem is complicated by the fact that the salmon may spend their lives in fresh water and in the ocean in various combinations of years, as 3 + 2 years, 3 + 3 years, 4 + 2 years, etc., so that these mortality rates refer to varying intervals of age. Thus there is no proof that the *annual* mortality rate is other than constant, and while no such deduction should be made from the data, it is evident that the age-specific mortality in fresh water can not be *very much* greater than in the ocean.

The data just presented have been grouped together because they give some conception of the form of the life table for certain species of fish, and the fact has been ignored that some of the information is not based on the age structure of the population, but on other kinds of evidence. This section may logically be concluded with a brief reference to the data for the fin whale, in which, as recent investigations have shown, the age of the female can be determined from the number of old corpora lutea in the ovary. By this method Wheeler (1934) arrived at the following as the age structure, observed over five seasons, 1926–1931, of the catch of female fin whales in the Antarctic:

Age	*Number caught*
3–4 years	130
5–6 years	95
7–8 years	72
9–10 years	53
11–12 years	37
13–14 years	28
15–16 years	10
17–18 years	4
19–20 years	1
21–22 years	1

The data imply (subject to the usual qualifications) a biennial mortality of about 26 per cent, increasing beyond the 15th year to much higher values. The author considers that the increased rate of loss with age is not real, but is due to failure of the older

whales to return from their winter quarters in the north. This belief may or may not be well founded, but one suspects it to be predicated on the idea that mortality, at least when it is primarily due to exploitation, is constant among animals with respect to age. Edser (to whom the statistical analysis is credited) assumed, for the purpose of a rough calculation of the necessary rate of replacement, that the mortality between birth and breeding age is also 26 per cent. The improbability of this assumption may be surmised by reference to the life table for the Dall sheep (Table 1). Edser's calculation has the great merit of yielding a minimal estimate of the alarming exploitation being conducted by the whaling industry in the Antarctic. More realistic assumptions would darken the picture even more. In any case the data can not yet be cast into a life table.

Miscellaneous Survivorship Data

By means of the mark-and-recapture method, Jackson (1936, 1939) has given an analysis of the population of a tsetse fly (*Glossina morsitans*) in Tanganyika. Jackson was chiefly interested in determining the size of the population and its fluctuations from season to season. The death of flies in the one-week intervals between marking and recapturing struck at the foundation of the method, which assumes no such mortality. But by taking a geometric average of the survival of marked flies in successive weeks, and extrapolating backward one week, the number theoretically recapturable on the date of marking was calculable. From this figure, the first term in a geometric survival series, the population could be directly calculated for each week during the year over which the study was conducted. But the flies were of unknown ages when first marked, being recognizable simply as adult males (plus a few females) having had their first meal. Evidently the operation was designed to smooth out of existence those systematic changes in age-specific mortality in which we are interested here. A few males were marked *before* their first meal, and the returns of these should permit the construction of a life table beginning at early adult life, but the data are not published separately, and in any case are probably inadequate statistically.

Two other points of interest are raised by this resourceful study. The first deals with the sex ratio in the wild population. Data on the return of marked females are not numerous, but so far as they go they suggest a considerably lower mortality than among males, the calculated survival ratio being 0.716 for females and ranging from 0.307 to 0.622 (depending on the season) for males. Expressed as mortality rates, these values are equal to 284, and between 693 and 378 per thousand flies per week, respectively. As a result, the normal sex ratio among the wild flies must vary from 1.5 to 2.0 in favor of females. Yet the sex ratio at emergence from the pupa is unity. There is no evidence that emigration, though always a complicating factor, is performed differentially by the two sexes, and it is not improbable that here also, as in man and in so many other animals studied in the laboratory, the female is significantly more long-lived than the male. The oldest fly captured lived 13½ weeks after marking, and was a female.

The second point is that Jackson used two methods for the calculation of a, the initial term in a survivorship series. "Instead of considering the survival curve of flies marked in any one week and recaptured in subsequent weeks . . . we can equally well consider the recaptures of flies marked in previous weeks and recaptured in any one week. Subject to sampling errors, both methods should give the same value of a." The difference between the latter "negative" method and the former "positive" method is essentially the difference between a vertical and a horizontal life table. The two methods, while equally applicable to a series of mortality rates assumed to be constant and equal to the geometric mean, as in this case, will give different results for animals of known ages if the age-specific mortality rates change with time. Inasmuch as the smoothed mortality rates for flies of all ages in the population appear to change regularly with the season, being greater in the dry season, real life tables constructed for similar populations would have to be distinguished with care.

An elaborate program of trapping and marking has been carried out with a population of long-tailed field mice (*Apodemus sylvaticus*) by Hacker and Pearson (1946). This sort of work is full of pitfalls, arising mainly from the fact that the traps are attractive to the mice and tend to drain them from distances which are frequently too great to be safely negotiated a second time. As the mice were of unknown ages when first marked, the results need not be summarized in any detail here, but some of the conclusions are of interest in giving an indication of the form of the field mouse life table in nature.

The "standard" survival ratio for mature mice,

as determined from repeated recaptures between December 1938 and April 1939, was 0.879, i.e., the mortality was 121 per thousand per month. But returns of these same mice in December and in March of the following year were much lower than expected from this ratio, implying that the mortality rate increases with age. Data for other years also show that the survival of the winter population is lower in the summer. Moreover, a study of returns of small, middle-sized, and large mice over three winter periods shows that the rates of loss are higher at both ends of the size distribution. Such scanty information can not be cast into a life table, but it is noticeable that a survivorship curve with two inflections fits well with that of the vole (*Microtus agrestis*), as established in the laboratory by Leslie and Ranson (1940).

Survival of Barnacles

Some of the advantages of the life table notation will now be illustrated by an analysis of the survivorship of the barnacle *Balanus balanoides*, as studied at St. Malo by Hatton (1938). The technical advantages presented by intertidal barnacles as objects of population research have been discussed in an earlier section, and a typical example of a barnacle life table has been given in Table 6. The relevant information about the biology of the species, as elucidated by Runnström (1925), Moore (1934), and Hatton, may be briefly summarized:

Balanus balanoides is a typical intertidal species, occurring primarily within the mean range of neap tides, where it often makes dense incrustations on all solid objects. It breeds in the fall, the nauplii being held in the mantle cavity for some time before liberation, while attachment and metamorphosis of the cyprid larvae takes place in the early spring, the exact time doubtless depending on the temperature. The attachment season lasts about six weeks. The intensity of attachment varies with the exposure to surf and the tidal level, being greatest at most exposed localities and at lower levels. The growth rate after attachment is greatest at lower tidal levels in the first year of life, but in subsequent years the growth at higher levels surpasses that at lower levels. Mortality, however, is also greater at lower levels, as shown by survival of barnacles of known ages from year to year, and thus the few barnacles at high levels (up to the mean level of high-water neap tides) are larger after a year's growth and live longer than those lower down. The maximum longevity appears to be about 5 years, but is much less at lower levels.

It is not clear which of these facts are simple responses to the physical ecology of the intertidal zone, and which are biotic effects. It is easy to suppose that the growth rate might be best at lower levels, where the barnacles are more continuously submerged and therefore take food more frequently. It is not so easy to explain the decline of growth rate with age at these levels (or the increase of growth rate with age at higher levels), unless it is in some way related to the population density; yet the growth differences are said to be observable in the absence of crowding. The low attachment densities at high levels presumably reflect the time necessary for a cyprid to attach, for the time available on any one tide decreases with the height. But after attachment the higher levels are exposed for longer periods to desiccation, direct sunlight, and rainwater, and the enhanced survival under these conditions is difficult to understand except as a function of the low population density.

The relation between population density and longevity is well known for certain laboratory animals. In general the length of life is curtailed by overcrowding (Pearl, 1946; Davis, 1945). In certain well-studied cases, however, the mean length of life has been found to increase at densities above the minimum, to decrease at very high densities, and to be greatest at some intermediate density (Pearl, Miner, and Parker, 1927). Pratt's proof of an optimum density for longevity of *Daphnia magna* (1943) is particularly convincing, since the densities were actually maintained constant throughout the life of the animals, and were not permitted to decrease with the gradual extinction of the initial cohort.

It is of considerable importance, therefore, to examine Hatton's data, which fortunately are published in full, for evidence of the relationship between longevity and population density in *Balanus balanoides*. Hatton studied nine different populations, allowed to settle on cleaned areas in 1930, and followed for three years. Three different levels were chosen at each of three localities as follows:

Localities	*Levels*
Décollé Ouest, exposed	II—mean high-water neap tide
Décollé Est, sheltered	III—half-tide
Cité, moderately sheltered	IV—mean low-water neap tide

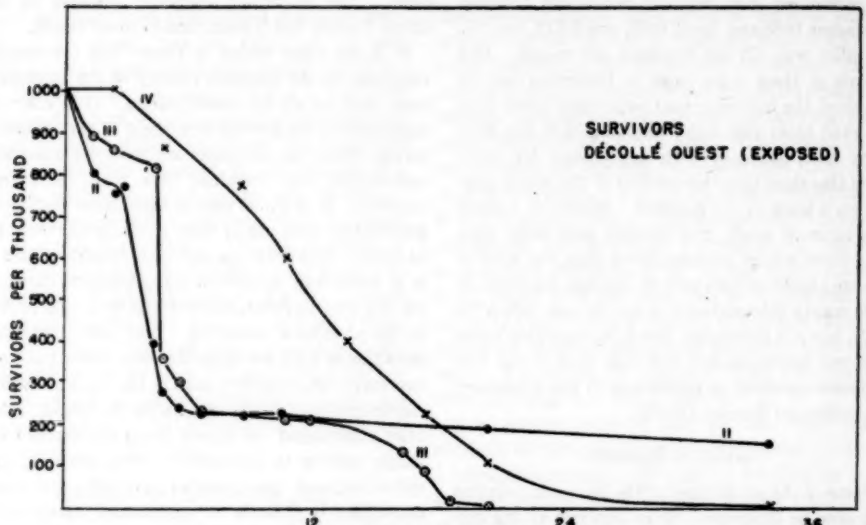

FIG. 6. SURVIVORSHIP (l_x) CURVES FOR THREE OF THE NINE POPULATIONS OF BALANUS BALANOIDES STUDIED AT ST. MALO BY HATTON (1938)

The locality, Décollé Ouest, is exposed to surf. The initial density of attachment, taken as the maximum density attained on May 15, 1930, was as follows: II (at mean high-water neap tide level), 790 per 100 cm²; III (at half-tide level), 2330 per 100 cm²; IV (at mean low-water neap tide level), 1500 per 100 cm².

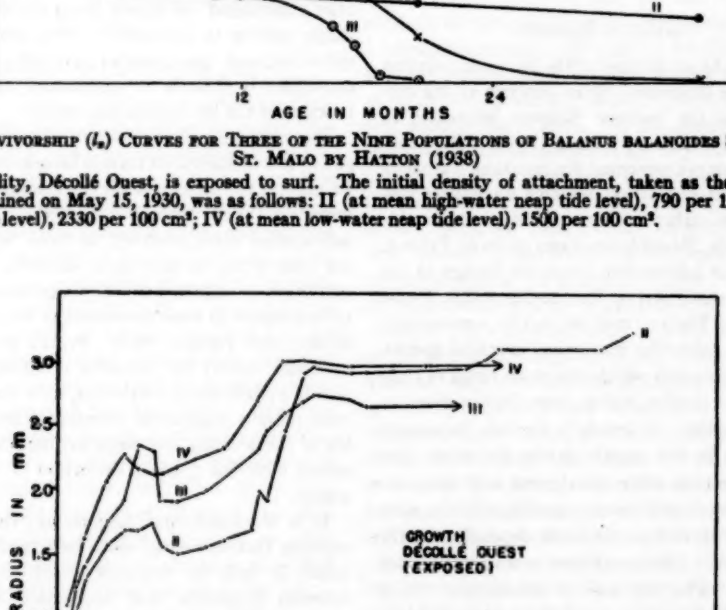

FIG. 7. GROWTH CURVES FOR BARNACLES CORRESPONDING TO THE THREE POPULATIONS OF FIG. 6, BUT OBTAINED FROM UNCROWDED SPECIMENS

The measurements began on April 1, 1930, and the points plotted are the average lengths (at the base, in the rostro-carinal axis), divided by 2. Each point represents an average of about 50 measurements.

Survivorship curves for the three populations at Décollé Ouest, converted to a relative (per thousand) basis, are shown by way of illustration in Fig. 6. It may be seen that the only population having surviving members after three years was that at Level II, where the initial population density was also least. The same relationship between density and survival was observed at the other two localities. But the matter is not so simple as it looks, for the growth rates must be taken into account in evaluating the degree of crowding on the areas. The corresponding growth curves for the Décollé Ouest populations are shown in Fig. 7. The measurements were made, not on the original populations, but on barnacles from adjacent cleaned areas, where the initial density was not allowed to exceed 100 per square decimeter, so that the growth was uninfluenced by crowding. The measurements given are the average lengths (in the rostro-carinal axis) of 50 individuals. This explains the curious fact that the sizes decrease during the winter: negative growth is biologically impossible in this case, and evidently there was a relatively great loss of older barnacles each winter. For purposes of calculation the radius of a barnacle has been taken to equal half the length, and the reasonable growth figures (ignoring negative increments) have been fitted to equations of the form

$$r = at^b$$

where r is the radius and t is the time in months.

Hatton's survivorship curves give the population per unit area at any time. The area at the base of an average uncrowded member of the population at any time can be calculated from the growth curve on the assumption, which is sufficiently accurate for the purpose, that the barnacles grow as expanding circles. The degree of crowding attained at any time can be evaluated as follows: (Grateful acknowledgment is due to Dr. John Ferry, of the University of Wisconsin, for the elegant following formulation.)

If barnacles of radius r settle at random within distance D of each other, and grow as expanding circles, so that at any time the radii r are equal, any barnacle which settles within distance $2r$ will be in contact with or overlap another. The number of binary contacts per barnacle will be given by:

$$\int_0^{2r} \frac{N}{A} \cdot 2\pi D \cdot dD$$

or, evaluating:

$$4\pi r^2 \frac{N}{A}.$$

where $\frac{N}{A}$ is the density per unit area. The total number of binary contacts per unit area will be this expression times the density times $\frac{1}{2}$ (because each contact is counted twice):

$$C = 2\pi r^2 \left(\frac{N}{A}\right)^2$$

This value C, the *crowding coefficient*, can be evaluated in terms of contacts per square centimeter, and is a function of the density and of the radius of an individual barnacle.

The crowding coefficients for Hatton's nine populations are given for selected times in Table 7, together with the observed density and the average radius of a barnacle at the same times. The expectation of life of a barnacle at the time in question is calculated by ordinary life table methods. Plotting C against e_x gives the graph shown in Fig. 8.

Evidently the population density, when considered in this way, has a definite effect on the survival of *Balanus balanoides*. The effect is not linear, but becomes less marked at higher degrees of crowding. Evidently, too, the relationship between survivorship and crowding is less definite at advanced ages, for the points for 18 months diverge from the curve.

It seems fairly certain that this discrepancy is due to the fact that the treatment has ignored the new settlements of barnacles which were added to the populations in subsequent years. The new arrivals can be treated by an extension of Dr. Ferry's mathematical approach, but it becomes necessary to decide whether there is any superincrustation, i.e., whether the area exposed to settlement, A, is (1) the same as the original area, (2) equal to the unoccupied area, or (3) has some intermediate value. No decision can be reached on this point from Hatton's account, which moreover gives only the second-year settlements, without subsequent data on the survival of the 1931 year-class or any information on the 1932 year-class. The data, however, are suggestive in that all the populations which diverge widely at 18 months from the curve of Fig. 8 received high second-year settlements, while the "good" points are from populations which received relatively little

recruitment in 1931. Since in general the populations with highest initial densities will receive the most considerable reinforcement in subsequent years, it is easy to imagine that over the years the effect of unit change of crowding on survival, $\frac{de_x}{dC}$, will be greatest for these populations. This argument carries the implication that a single curve, such as the one drawn in Fig. 8, is an illusion. But only further work will permit a deeper analysis of this exceptionally interesting case.

TABLE 7

Population density, calculated radius, crowding coefficients, and expectation of life at selected times for nine populations of Balanus balanoides at St. Malo
Original data from Hatton (1938)

POPULATION (*Locality and Level*)	t TIME (*months*)*	N/A DENSITY PER CM^2	r RADIUS (mm.)	C CROWDING COEFFICIENT: *contacts per* $cm^2 = 2\pi r^2(N/A)^2$	e_x EXPECTATION OF FURTHER LIFE (*months*)†
Décollé Est II	0	4.0	1.08	1.17	23.1
	6	2.4	1.65	0.98	29.6
	12	2.1	1.92	1.02	27.2
	18	1.9	2.11	1.01	23.7
	24	1.5	2.27	0.73	23.1
	30	1.5	2.39	0.81	17.7
Décollé Est III	0	11.9	1.12	11.24	13.8
	6	8.3	1.59	10.87	12.8
	12	5.4	1.80	5.92	12.6
	18	4.2	1.94	4.09	9.1
	24	2.0	2.06	1.07	9.9
	30	1.0	2.16	0.29	12.2
Décollé Est IV	0	15.0	1.41	27.91	9.5
	6	8.4	1.80	14.35	7.5
	12	4.8	1.97	5.61	4.9
	18	1.8	2.08	0.88	1.2
Décollé Ouest II	0	7.9	1.34	7.07	11.0
	6	1.9	1.82	0.75	31.2
	12	1.7	2.03	0.75	28.5
	18	1.5	2.18	0.67	24.5
	24	1.4	2.29	0.65	20.3
	30	1.3	2.38	0.61	15.8
Décollé Ouest III	0	23.3	1.50	76.28	7.0
	6	6.3	1.94	9.34	8.7
	12	4.9	2.12	6.81	4.7
	18	1.2	2.25	0.46	1.0
Décollé Ouest IV	0	15.0	1.74	42.55	12.6
	6	12.6	2.20	48.41	8.2
	12	7.3	2.40	19.35	5.6
	18	3.0	2.54	3.65	3.7
	24	0.6	2.64	0.16	2.9
	30	0.08	2.73	0.03	2.0
Cité II	0	10.0	1.24	9.61	14.3
	6	3.4	1.67	2.03	28.6
	12	2.9	1.89	1.88	27.2
	18	2.8	2.00	1.97	22.5
	24	2.5	2.10	1.73	19.0
	30	2.2	2.19	1.45	15.2
Cité III‡	0	22.0	1.32	53.22	12.1
	6	16.7	1.66	48.05	9.1
	12	10.1	1.80	20.70	6.7
	18	5.1	1.89	5.85	4.7
	24	0.7	1.96	0.11	1.8
Cité IV	0	23.8	1.44	74.10	11.2
	6	12.9	1.71	30.68	12.2
	12	11.0	1.82	25.29	7.9
	18	6.1	1.90	8.41	5.4
	24	2.6	1.95	1.62	2.5

* These are the times corresponding to the density figures (read from the survivorship curves), beginning at 0 = 15 May. The growth curves begin on 1 April, and the time values for radius as stated are actually 1.5, 7.5, 13.5, 19.5, 25.5, and 31.5 months.

† Computed on the assumption that those populations still having surviving members after 3 years would have terminated at 5 years.

‡ Life table for this population given in Table 6.

Returning to the original question, whether there is a density above the minimum which is optimal for the longevity of *Balanus balanoides* in nature, Fig. 8 indicates that there is not. The expectation of life is greatest when the crowding coefficient is

least, and the curve does not rise before it falls. This negative evidence is probably not conclusive, and a larger body of data, preferably obtained under conditions which are less variable as regards factors other than crowding, might give a different answer. But there is no particular reason to expect that a species such as this one would benefit greatly from mutual support. It is possible to point to another barnacle in which the case may be otherwise. This is *Chthamalus stellatus*, which flourishes best at an intertidal level above that of this phenomenon was never observed with *Chthamalus*.

Hatton's work included survival studies of *Chthamalus* as well as of *B. balanoides*, but as the longevity of the former is greater (see also Moore and Kitching, 1939), few of the populations had run their courses when the experiments were terminated at the end of three years. As a result, the expectation of life cannot be calculated with any confidence. Annual mortality rates for six populations (three at Level I, above the *B. balanoids*

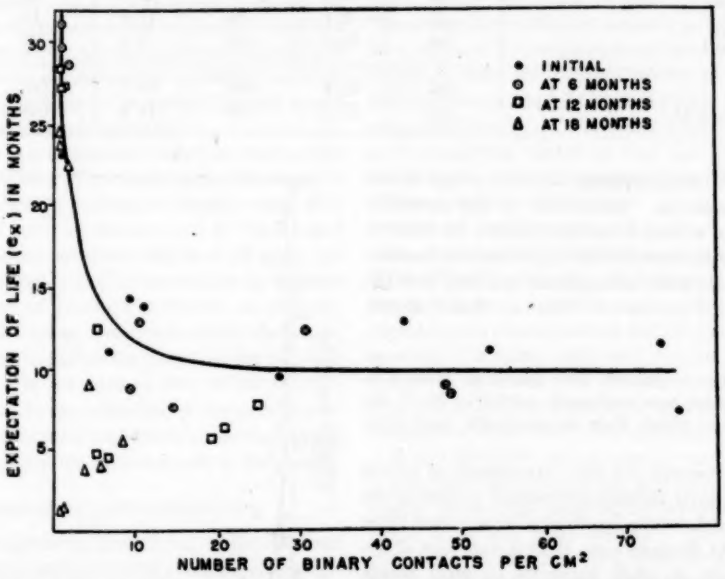

FIG. 8. RELATION BETWEEN EXPECTATION OF LIFE (e_x) OF BALANUS BALANOIDES AT SELECTED TIMES AND THE CROWDING COEFFICIENT (CONTACTS PER SQUARE CENTIMETER) AT THE SAME TIME
Data in Table 7, calculated from data of Hatton.

B. balanoides. Here it is exposed to sun and drought for long periods, and Monterosso (1930) has found that it is remarkably hardy, specimens having survived for three years on a laboratory table with only one or two days' immersion in sea water each month. Hatton suggests that the chances of survival of a young *Chthamalus* are improved if it settles in the shade of a larger individual; at any rate, the larvae tend to attach in the shade in greater numbers, when ridges of cement are built upon the rocks. Moreover, while attached and growing *B. balanoides* were frequently found to dislodge each other from the substratum, zone; and three at Level II, where densities of *B. balanoides* were low) are arranged in Table 8 for direct comparison with the density. The table shows that the populations having very low densities suffered higher mortality rates on the average than those below the dashed line in the table, which had higher densities. The difference is more pronounced when the first year's mortality is omitted, but in neither case is the difference significant statistically. The predicted relation between density and survivorship of *Chthamalus* is therefore not proven, and the question remains open.

Mention has been made in an earlier section of a

defect inherent in the life tables calculated from experiments like Hatton's, in that the observations much greater, reaching 95 per cent (survival ratio 0.05) at the greatest densities observed.

TABLE 8

Annual mortality of Chthamalus stellatus at St. Malo in relation to population density
Data from Hatton (1938), Tables XXXVI–XXXVIII

POPULATION (LOCALITY AND LEVEL)	FIRST YEAR		SECOND YEAR		THIRD YEAR	
	Initial density per 100 cm²	Mortality %	Density per 100 cm²	Mortality %	Density per 100 cm²	Mortality %
Décollé Ouest I	21	4.8	20	10.0	18	16.6
Décollé Est II	39	10.3	35	20.0	28	28.6
Cité I	44	9.1	40	17.5	33	9.1
Décollé Est I	48	31.2	33	9.1	30	36.7
Cité II	184	11.4	163	13.5	141	8.5
Décollé Ouest II	270	17.4	223	11.2	198	14.1

start with metamorphosis, and the pelagic larval life is neglected. Some idea of the mortality during the earliest attachment stage, the interval between attachment of the cyprid and its transformation to an adult barnacle, can be gained from the unpublished studies of Weiss at Miami Beach, Florida.

Permission to present these results in advance of publication has been courteously granted by Mr. C. M. Weiss of the Woods Hole Oceanographic Institution.

Weiss observed the daily attachment of cyprid larvae (mainly *Balanus improvisus*) to glass slides exposed each twenty-four hours for more than three years. At the same time, records were kept of the attachment of adult barnacles to glass panels exposed each month at the same locality. The time required for a cyprid to grow into an adult barnacle large enough to be counted varies from one to two weeks according to the season. By summing the daily cyprid attachments over a two- to three-week period, therefore, and comparing the figures with the number of adult barnacles found on the panels at the end of the month, a measure of the survival between cyprid and adult stages was obtained. The results are shown in Fig. 9, the ratio of surviving barnacles to cyprids being plotted against the intensity of cyprid attachment. The curve shows clearly that a cyprid's chances of successful growth to maturity vary inversely with the density of attachment: when few cyprids attach most or all of them survive to become barnacles, but when cyprid densities are high the mortality is

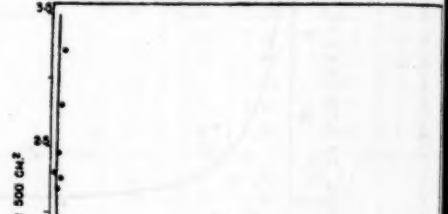

FIG. 9. RELATION BETWEEN SURVIVAL OF BARNACLES TO MATURITY AND THE INTENSITY OF CYPRID ATTACHMENT AT MIAMI BEACH, FLORIDA

Cyprid attachment was observed on glass slides exposed for twenty-four hours; the barnacles were counted on glass panels exposed for twenty-eight days. Daily cyprid attachment figures have been summed over two or three weeks, according to the season, for comparison with the number of surviving barnacles. From unpublished results of C. M. Weiss, Woods Hole Oceanographic Institution.

Inspection of the scale of barnacle:cyprid ratios in Fig. 9 brings out an apparent paradox in that ratios above 1.0 were frequently observed, i.e., in

some months more barnacles survived than can be accounted for from the cyprids attaching. Weiss takes this to mean that the longer exposure of the one-month panels made them more suitable for the attachment of barnacles than the twenty-four-hour slides. Such a result of exposure can reasonably be attributed to the facilitating effect of a "slime film" (of diatoms and bacteria) on the attachment of larvae of fouling organisms, an effect of which there is independent evidence. This complication, interesting as it is, makes it impossible to use the data further for an analysis of the mortality of barnacles in early stages. For if in any month more cyprids attached to the panels during certain days than the daily figures show, the barnacle:cyprid ratio will give too low an estimate of the mortality; but such an error is not likely to be systematic, and would have to be evaluated separately.

Although it is abundantly clear that much of the mortality suffered by natural stands of barnacles is directly related to population density, much of it certainly is not. Predators, such as whelks and limpets, account for many deaths at all ages, and physical factors, including desiccation in summer and abrasion by boulders in winter, are also important. We are not yet able to dissect the barnacle life tables to expose the causes of death. It is enough for the purposes of this review to have pointed out: (1) the attraction of barnacle incrustations as objects for population research; and (2) the advantages of life table methods in their study.

COMPARISONS AND CONCLUSIONS

It is now apparent that, owing to the different ways in which data have been collected, all ecological life tables are not strictly comparable among themselves, and a summary graph containing survivorship curves for all the species considered would be misleading in the extreme. It is also true, though not so obvious, that within any one group of life tables, such as the "d_x observed" group or the "l_x observed" group, comparisons are also apt to lead us astray. For the various life tables so far constructed *take their origin at different biological ages*. Is it fair to compare a bird life table, beginning at early adult life, with the Dall sheep life table, which begins at birth, or with the life table of a sessile invertebrate, beginning at attachment or metamorphosis? Evidently not; birth itself is not an age of universal biological equivalence outside the placental mammals, and for a broader view of comparative mortality the only safe point of reference would be the fertilized ovum.

This reservation should perhaps not be applied too literally. Human and insect survivorship curves have been compared in the past, and the comparison is instructive, despite the very different origins and statistical foundations of the life tables. It is possible to compare the survivorship of an insect such as *Drosophila*, beginning at sexual maturity, with that of a laboratory population of black widow spiders (Deevey and Deevey, 1945) which enter their life table at the antepenultimate instar when the sexes become distinguishable. The comparison, which of course is purely qualitative, suggests that organisms are born at different points on their survivorship curves, so to speak, and that heavy juvenile mortality may be carried over into later life as a neotenic character. This is the statistical aspect of that ancient proverb which Cicero quotes disparagingly, "grow old early if you would be old long."

The cognate suggestion has been made that altricial and praecocial birds should be examined in the light of this hypothesis. Unfortunately, such a comparison cannot yet be made. We now have life tables of a sort for several altricial species, (song sparrow, Turdidae, etc.) and for at least one markedly praecocial bird (the pheasant), but the data are lacking for those early ages at which the comparison might have some meaning.

If bird life tables cannot even be compared with one another except from adult ages onward, we can hardly make very enlightening comparisons between birds and other animals. The ecological information is deficient, to a variable degree it is true, but still deficient, for the early ages; and this is the segment of the life curve on which future investigators must concentrate their efforts. The most that can be said at present is that the more nearly complete natural life tables (Dall sheep, barnacle, rotifer) give no ground for supposing that ecological life tables are invariably diagonal, as is so often assumed *faute de mieux* in fisheries work. Increases and decreases in mortality rate must be expected at any age, as the laboratory populations also show.

Related to the paucity of data near the beginning of life is the remarkable absence, among the examples adduced, of life curves approaching Pearl's "Type III" distribution. Only the synthetic survivorship curve for the song sparrow calculated from the egg stage (Fig. 5) shows the pronounced

dip in early life associated with this form. But Sette's data for the mackerel show that pelagic fishes actually fall here; the barnacle and the rotifer might also fall here if their life tables were complete, and ecologists will await with interest the construction of a life table for the oyster.

It is pertinent to inquire whether the ecological life tables throw any light on the relation between the different theoretical types of survivorship curve (Fig. 1). It is a well known property of human longevity that while the mean age at death shows extreme variation among different populations, ancient and modern, and has shown a marked increase in Europe and the United States in recent decades, the maximum life span is fixed (Dublin and Lotka, 1935; Pearl, 1946). In other words, the human survivorship curve is like a rubber band, fixed at points corresponding to birth and about the 115th year, and while medical science has succeeded in stretching the band more and more toward the upper side of Fig. 1, the termini have remained fixed as they were in Roman times.

If the maximum life span is fixed for all species by physiological considerations, as it probably is, the mean life span is not. Lack (1943b) points out that a young blackbird in nature can expect to live for but 8 per cent of its potential life span, compared to some 60 per cent for a juvenile human. Evidently there is much room for improvement in the expectation of life of species in the wild, to judge from the known longevity of some of them in captivity. As has been shown, birds as a group seem to have remarkably diagonal survivorship curves, the mortality being constant for a given bird with respect to age, and for all birds so far studied with respect to units of mean life span. This means that experience of life is of no use to a bird in avoiding death, although Farner (1945) raises the question whether the apparent diagonality may not be a result of insufficient data.

The case is quite otherwise with the Dall sheep, with its low mortality during middle life. This species seems to have evolved a mechanism for stretching its mean life span toward the maximum. Whether this has come about because of intimate demographic contact with a single important predator or for some other reason is a "puzzling question." Such an enhancement of survival during the years of maximum reproductive efficiency has important implications for the whole population problem, including the question of the nature of internally generated cycles; but on this matter little more can be said than that the mathematical methods are available for a study of the relation between the fertility schedule and the death rate structure when the data come to hand (Leslie, 1945).

Bodenheimer (1938) has maintained that not only is the maximum life span fixed for a species, but that the potential mean longevity is the same as the maximum. On this view a species has a "physiological life table" of the negatively skew rectangular type, and a more diagonal or positively skew "ecological life table" which is the result of premature mortality. All such mortality is thus regarded as environmentally produced. This position is probably not tenable as a basis for a general theory of mortality, since there appears to be no reason why "endogenous senescence" (in Pearl's phrase) should be strictly confined to the end of the life span. Even in genetically homogeneous populations the members are not identical, and endogenous senescence must have a probability distribution which is not necessarily regular, though it may well be more so than that of "exogenous senescence." In any case, since we can not observe physiological survivorship except in an environment of some sort, Bodenheimer's conception would appear to be non-operational.

The question at issue resolves itself into the relation between the mean and the maximum life span. In theory there is a simple answer: the ratio of the maximum to the mean approaches 1.0 as a limit for Type I, approaches infinity for Type III, and its actual value for Type II depends on the level at which we permit the abscissa of Figure 1 to intersect the ordinate. If we decide to terminate the diagram when a cohort of 1000 individuals has been reduced to 1, a diagonal survivorship line will intersect the age axis at some point above 1.0, but if we start with 100,000 individuals the same line projected will give a higher maximum age for the last survivor. Reference to Figs. 2, 4, and 5 will make the matter plain, when it is realized that an age value of +100 per cent deviation from the mean corresponds to a maximum: mean ratio of 2.0, one of +500 per cent corresponds to a ratio of 6.0, etc. In all cases we have started with 1000 individuals, simply because the samples were of less than 1000 to begin with, and only three places at most can be significant. Had we larger samples available the maximum life span, as shown on the abscissas of Figs. 2, 4, and 5, would have been higher for a given mortality rate.

It should now be clear that we cannot yet formulate the relationship exactly. One stumbling block is that with a cohort of 1000 individuals the 1 per thousand level has lost all semblance of reliability: taking Fig. 4 as an illustration, we might well find that the last hundred birds in a cohort of 100,000 really have gained some benefit from their accumulated experience of life, and die at decreasing rates. This would mean that the true survivorship curve is concave. It is equally possible that these hypothetical survivors of a larger cohort would be found to be decrepit, and to die at greatly accelerated rates, giving a convexity to the tail of the survivorship curve.

The other obstacle to an exact formulation is that the mean length of life is calculated from different starting points in the cases before us, so that an observed relation between maximum and mean has no quantitative significance as a basis of comparison between species. Empirically, it will eventually be possible to divide animals into three groups, somewhat as follows: those in which the maximum length of life is between two and six times the mean may be called "thrifty" (the Dall sheep, rotifer, and barnacle might fall here, along with most of the populations studied in the laboratory); those in which the ratio lies between 6.0 and 15.0 (as perhaps in song birds) might be called "indifferent"; those which on the average realize less than one-fifteenth of their maximum life span might be called "prodigal." These limits would have to be arbitrarily defined by the age (in units of mean life span) attained by the oldest individual in a cohort of 1000. But such limits can not yet be specified, and the values assigned are pure guesses, based on data which we know to be inadequate, and intended simply for illustration.

So far we have confined our attention almost exclusively to the *form* of the life table, and have said very little about the *causes* of death other than to imply that they are suitable subjects for ecological investigation. Authors who have discussed the matter in some detail for particular cases have not reached very satisfactory general conclusions. Thus Ricker (1945) decides that "senile death is an everyday occurrence among bluegills and crappies," and Lack (1943a) says, "Who killed cock robin is, for the most part, still a mystery." Errington (1945, 1946) has argued energetically against the generally accepted view that predation is responsible for the maintenance of population size among vertebrates, believing that intraspecific competition demands more attention than it has received. Predation, in Errington's opinion, falls principally on the very young, the very old, and the diseased, i.e., on the insecure members of the population, who might otherwise have died in any event. Clearly, the task of constructing better life tables for natural populations, though an important prerequisite to the study of mortality, is not a substitute for such a study. Even so interesting a series of life tables as is available for *Balanus balanoides* proves to be unsatisfactory when it is realized that they all start at the same season, and the survivors are exposed to winter conditions at the same ages. What would happen to the survivorship curves if such animals were caused to be born out of season can only be found out by painstaking work. And until such questions, and many others, are answered, we will not be ready to establish a general theory of mortality.

"Sed omnes una manet nox
et calcanda semel via leti."

SUMMARY

Materials for the study of the age distribution of mortality are available from several natural populations of animals. Attempts are made, in most instances for the first time, to condense this information into life tables, showing for each age interval the number of deaths, the number of survivors, the mortality rate, and the expectation of further life of members of an initial cohort of 1000 individuals. These life table functions, especially when age is expressed in terms of units of the mean life span rather than in years, months, or days, should afford the best basis for comparing populations of the same and of different species in respect to their order of dying. Unfortunately, the ecological information is of unequal value in the various cases, and only limited and tentative comparisons can be made.

According to the methods used in collecting the information, the species studied fall into three groups: (a) those in which the *age at death* (d_x) is known, with fair accuracy, at least beyond certain ages (Dall mountain sheep, the sessile rotifer *Floscularia conifera*, and several species of birds); (*b*) those in which the *number of survivors* (l_x) out of a definite initial number has been directly observed at frequent intervals (barnacles, song sparrow, pheasant, snowshoe rabbit); (*c*) those in which the *age structure* (L_x) of the population is observed at a specified time, and the age at death is inferred from

the shrinkage between age classes (cormorant, many fish, fin whale). Information of type (*b*) is comparable to that obtainable from a laboratory experiment, provided only that the season of birth is sharply defined, and can be used without qualification for the construction of a life table. Information of types (*a*) and (*c*) can be so used only upon the assumption that the age structure of the population does not change with time.

Both in nature and in the laboratory, animals differ characteristically in their order of dying. When the mortality rate at all ages is constant, the survivorship (l_x) curve is diagonal on semi-logarithmic graph paper. Such a curve is found for many birds from adult stages onward; the mortality of adult birds is about 320 per thousand per hundred centiles of mean life span. If the constant age-specific mortality rate observed for the first few years of adult life is really maintained throughout life, the oldest bird in a cohort of 1000 lives 6.6 times as long as the average bird. Not all animals resemble birds in this respect, however, although many (e.g., fish) are assumed to do so. The Dall sheep, the rotifer, and possibly the barnacle are more like civilized man in that they seem to have evolved a mechanism for stretching the mean life span toward the maximum, so that the survivorship curve is convex. In these cases the maximum life span (among a sample of 1000) is only two or three times the mean. On the other hand there are undoubtedly species in which juvenile mortality is very heavy, but the few survivors to advanced ages die at reduced rates. This J-shaped or concave survivorship line, with the maximum longevity perhaps 15 or more times the mean, is presumed to characterize the oyster and other species, but it has not yet been formally recognized either in the laboratory or in nature. The closest approach to it, so far, is found when the survival of song sparrows is reckoned from the egg stage; but the mackerel will almost certainly provide an even better example.

Detailed comparisons between species cannot yet be made, partly because of the diverse statistical foundations of the life tables and partly because the data begin at different biological ages (birth, hatching, metamorphosis, sexual maturity, etc.) in the different cases. In all cases it is the youngest ages about which we know least, and ecologists should therefore concentrate their efforts on this segment of the life span of animals in nature.

The best examples of ecological life tables come from Hatton's work with the barnacle *Balanus balanoides*, which is a very favorable object for population research. By way of emphasizing the advantages of life table notation, Hatton's data are manipulated so as to show the relationship between longevity and population density. A theory of two-dimensional crowding by radially growing circular objects is first derived from geometric considerations, and it is then possible to relate the expectation of life (e_x) of a barnacle to a factor, called the *crowding coefficient*, which incorporates both the population density and the rate of growth. The number of barnacle populations available for study is limited, and Hatton's experiments were designed for a different purpose, but so far as the data go there is no evidence of an optimum density for survival of *B. balanoides*. Reasons are given for supposing that *Chthamalus stellatus* may prove to have such an optimum density.

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This article had its inception as part of a symposium, entitled "Life Tables and Their Application," held at Boston on December 27, 1943, under the joint auspices of the Ecological Society of America and the American Statistical Association. The present version has been completely reworked in the light of other contributions to the symposium. Remarks made at the meeting by Margaret Merrell, C. P. Winsor, and W. E. Ricker have been particularly helpful. Much has been learned also from later conversations with David Lack, G. E. Hutchinson, and Daniel Merriman. The author retains sole responsibility, however, for errors which may still remain.

LIST OF LITERATURE

AUSTIN, O. L. 1942. The life span of the common tern (*Sterna hirundo*). *Bird-Banding*, 13: 159–176.

BARNABY, J. T. 1944. Fluctuations in abundance of red salmon, *Oncorhynchus nerka* (Walbaum) of the Karluk River, Alaska. *U. S. Fish & Wildlife Service, Fishery Bull.*, 50 (39): 235–295.

BERTRAM, G. C. L. 1940. The biology of the Weddell and Crabeater Seals, with a study of the comparative behaviour of the Pinnipedia. *Brit. Mus.*

(*Nat. Hist.*): *British Graham Land Expedition 1934–37, Sci. Rep.*, 1 (1): 139 pp., pls. 1–10.

BODENHEIMER, F. S. 1938. *Problems of animal ecology*. vi + 183 pp. Oxford Univ. Press, London.

DAVIS, M. B. 1945. The effect of population density on longevity in *Trogoderma versicolor* Creutz. (=*T. inclusa* Lec.). *Ecology*, 26: 353–362.

DEEVEY, G. B., and E. S. DEEVEY. 1945. A life table for the black widow. *Trans. Conn. Acad. Arts Sci.*, 36: 115–134.

DUBLIN, L. I., and A. J. LOTKA. 1935. *Length of life. A study of the life table*. xxii + 400 pp. Ronald Press, New York.

EDMONDSON, W. T. 1945. Ecological studies of sessile Rotatoria, Part II. Dynamics of populations and social structures. *Ecol. Mon.*, 15: 141–172.

ERICKSON, M. M. 1938. Territory, annual cycle, and numbers in a population of wren-tits (*Chamaea fasciata*). *Univ. Calif. Pub. Zool.*, 42 (5): 247–334, pls. 9–14.

ERRINGTON, P. L. 1945. Some contributions of a fifteen-year local study of the northern bobwhite to a knowledge of population phenomena. *Ecol. Mon.*, 15: 1–34.

——. 1946. Predation and vertebrate populations. *Quart. Rev. Biol.*, 21: 144–177, 221–245.

ESCHMEYER, R. W. 1939. Analysis of the complete fish population from Howe Lake, Crawford County, Michigan. *Papers Mich. Acad. Sci. Arts Lett.*, 24 (II): 117–137.

FARNER, D. S. 1945. Age groups and longevity in the American robin. *Wilson Bull.*, 57: 56–74.

GEISER, S. W. 1923. Evidences of a differential death rate of the sexes among animals. *Amer. Midl. Nat.*, 8: 155–163.

——. 1924. The differential death-rate of the sexes among animals, with a suggested explanation. *Wash. Univ. Stud.*, 12: 73–96.

GREEN, R. G., and C. A. EVANS. 1940. Studies on a population cycle of snowshoe hares on the Lake Alexander area. I. Gross annual censuses, 1932–1939. *J. Wildl. Man.*, 4: 220–238. II. Mortality according to age groups and seasons. Ibid., 4: 267–278. III. Effect of reproduction and mortality of young hares on the cycle. Ibid., 4: 347–358.

HACKER, H. P., and H. S. PEARSON. 1946. The growth, survival, wandering, and variation of the long-tailed field mouse, *Apodemus sylvaticus*. II. Survival (By H. P. Hacker). *Biometrika*, 33: 333–361.

HATTON, H. 1938. Essais de bionomie explicative sur quelques espèces intercotidales d'algues et d'animaux. *Ann. Inst. Océanogr.*, 17: 241–348.

HODGE, W. B. 1857. On the rates of interest for the use of money in ancient and modern times. (Part I). *Assurance Mag. & J. Inst. Act.*, 6: 301–333.

JACKSON, C. H. N. 1936. Some new methods in the study of *Glossina morsitans*. *Proc. Zool. Soc. Lond.*, 1936: 811–896, pls. 1–12.

——. 1939. The analysis of an animal population. *J. Anim. Ecol.*, 8: 238–246.

JENSEN, A. J. C. 1939. On the laws of decrease in fish stocks. *Cons. Per. Intern. Explor. Mer, Rapp. Proc.-Verb.*, 110 (8): 85–96.

KORTLANDT, A. 1942. Levensloop, samenstelling en structuur der Nederlandse aalscholver bevolking. *Ardea*, 31: 175–280.

KRAAK, W. K., G. L. RINKEL, and J. HOOGERHEIDE. 1940. Oecologische bewerking van de Europese ringgegevens van de Kievit (*Vanellus vanellus* (L.)). *Ardea*, 29: 151–175.

LACK, D. 1943a. *The life of the robin*. 200 pp. H. F. & G. Witherby, London.

——. 1943b. The age of the blackbird. *Brit. Birds*, 36: 166–175.

——. 1943c. The age of some more British birds. *Brit. Birds*, 36: 193–197, 214–221.

——. 1946. Do juvenile birds survive less well than adults? *Brit. Birds*, 39: 258–264.

LAURIE, A. H. 1937. The age of female blue whales and the effect of whaling on the stock. *Discov. Rep.*, 15: 223–284.

LEOPOLD, A., T. M. SPERRY, W. S. FEENEY, and J. S. CATENHUSEN. 1943. Population turnover on a Wisconsin pheasant refuge. *J. Wildl. Man.*, 7: 383–394.

LESLIE, P. H. 1945. On the use of matrices in certain population mathematics. *Biometrika*, 33: 183–212.

——, and R. M. RANSON. 1940. The mortality, fertility, and rate of natural increase of the vole (*Microtus agrestis*) as observed in the laboratory. *J. Anim. Ecol.*, 9: 27–52.

MACARTHUR, J. W., and W. H. T. BAILLIE. 1932. Sex differences in mortality in *Abraxas*-type species. *Quart. Rev. Biol.*, 7: 313–325.

MACDONELL, W. R. 1913. On the expectation of life in ancient Rome, and in the provinces of Hispania and Lusitania, and Africa. *Biometrika*, 9: 366–380.

MARSHALL, H. 1947. Longevity of the American herring gull. *Auk*, 64: 188–198.

MONTEROSSO, B. 1930. Studi cirripedologici, VI. Sul comportamento di "Chthamalus stellatus" in diverse condizioni sperimentali. *Atti. R. Accad. Naz. Lincei Rend., Ser. 6, Cl. Sci. Fis. Mat. Nat.*, 11 (5): 501–505.

MOORE, H. B. 1934. The biology of *Balanus balanoides*. I. Growth rate and its relation to size, season, and tidal level. *J. Mar. Biol. Ass.*, n. s., 19: 851–868.

MOORE, H. B. 1935. A comparison of the biology of *Echinus esculentus* in different habitats. Part II. *J. Mar. Biol. Ass.*, n. s., 20: 109–128.

——, and J. A. KITCHING. 1939. The biology of *Chthamalus stellatus* (Poli). *J. Mar. Biol. Ass.*, n. s., 23: 521–541.

MURIE, A. 1944. *The wolves of Mount McKinley.* (Fauna of the National Parks of the U. S., Fauna Series No. 5, xx + 238 pp.) U. S. Dept. Int., Nat. Park Service, Washington.

NICE, M. M. 1937. Studies on the life history of the song sparrow. Vol. I. A population study of the song sparrow. *Trans. Linn. Soc. N. Y.*, 4: vi + 247 pp.

PAYNTER, R. A. (*in press*). The fate of Kent Island herring gulls. *Bird-Banding*, (in press).

PEARL, R. 1940. *Introduction to medical biometry and statistics.* 3rd ed. xv + 537 pp. W. B. Saunders, Philadelphia and London.

——. 1946. *Man the animal.* 128 pp. Principia Press, Bloomington.

——, and J. R. MINER. 1935. Experimental studies on the duration of life. XIV. The comparative mortality of certain lower organisms. *Quart. Rev. Biol.*, 10: 60–79.

——, ——, and S. L. PARKER. 1927. Experimental studies on the duration of life. XI. Density of population and life duration in *Drosophila*. *Amer. Nat.*, 61: 289–318.

——, T. PARK, and J. R. MINER. 1941. Experimental studies on the duration of life. XVI. Life tables for the flour beetle *Tribolium confusum* Duval. *Amer. Nat.*, 75: 5–19.

PRATT, D. M. 1943. Analysis of population development in *Daphnia* at different temperatures. *Biol. Bull.*, 85: 116–140.

RAITT, D. S. 1939. The rate of mortality of the haddock of the North Sea stock. *Cons. Perm. Intern. Explor. Mer, Rapp. Proc.-Verb.*, 110 (6): 65–79.

RICKER, W. E. 1940. Relation of "catch per unit effort" to abundance and rate of exploitation. *J. Fish. Res. Bd. Canada*, 5: 43–70.

——. 1944. Further notes on fishing mortality and effort. *Copeia*, 1944: 23–44.

——. 1945. Natural mortality among Indiana bluegill sunfish. *Ecology* 26: 111–121.

RUNNSTRÖM, S. 1925. Zur Biologie und Entwicklung von *Balanus balanoides* (Linné). *Bergens Mus. Aarbok* 1924–25, *Naturvid. Raekke*, (5). 46 pp.

RUSSELL, E. S. 1942. *The overfishing problem.* vii + 130 pp. Cambridge Univ. Press, Cambridge.

SETTE, O. E. 1943. Biology of the Atlantic mackerel (*Scomber scombrus*) of North America. Part I: Early life history, including the growth, drift and mortality of the egg and larval populations. *U. S. Fish Wildl. Serv. Fish. Bull.*, 50 (38): 147–237.

THOMPSON, W. F., and F. H. BELL. 1934. Biological statistics of the Pacific halibut fishery. (2) Effect of changes in intensity upon total yield and yield per unit of gear. *Rep. Intern. Fish. Comm.*, 8: 49 pp.

TRENERRY, C. F. 1926. *The origin and early history of insurance, including the contract of bottomry.* xiv + 330 pp. P. S. King & Son, London.

WHEELER, J. F. G. 1934. On the stock of whales at South Georgia. *Discov. Rep.*, 9: 351–372.

NEW BIOLOGICAL BOOKS

The aim of this department is to give the reader brief indications of the character, the content, and the value of new books in the various fields of Biology. In addition there will occasionally appear one longer critical review of a book of special significance. Authors and publishers of biological books should bear in mind that THE QUARTERLY REVIEW OF BIOLOGY *can notice in this department only such books as come to the office of the editor. The absence of a book, therefore, from the following and subsequent lists only means that we have not received it. All material for notice in this department should be addressed to H. B. Glass, Assistant Editor of* THE QUARTERLY REVIEW OF BIOLOGY, *Department of Biology, The Johns Hopkins University, Baltimore 18, Maryland, U. S. A.*

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REVIEWS AND BRIEF NOTICES

GENERAL BIOLOGY: PHILOSOPHY AND EDUCATION

HUMAN DESTINY.

By Lecomte du Noüy. Longmans, Green and Company, New York, London, and Toronto. $3.50. xii + 289 pp. 1947.

Yet another book on religion by a scientist does not necessarily merit much attention. However, when its publicity implies that it is "a scientific work . . . which marks a new epoch in human thought"; when it is mentioned in the same sentence with the works of Descartes, Newton, Darwin, and Einstein; when a leading American scientist permits his remarks to appear on the cover jacket, saying, "A book of such fundamental grasp and insight as cannot be expected to appear more than once or twice in a century" (Robert A. Millikan—whose opinions, however, may be much more important in physics than religion) —then indeed the book must be examined, and examined critically, by scientists.

Du Noüy has the distinction of being a biologist, whereas most of the other scientists who have pronounced on religious matters have been physicists. It seems entirely fitting that an attempt to bring biological evolution within the scope of religion should be made by a biologist. Even a biologist whose own work has not been especially in the field of evolution might be expected to have a better grasp of the subject than, say, a physicist.

This is a curious book. Its scope is enormous. It first deals with scientific method. It treats of the origin of life, the whole panorama of biological evolution, the emergence and present status of man and his future, though little that is concrete is said about his destiny, less than we are led to expect from the title. A large part of the book is devoted to a sermon on morality, which, if it did not sound quite so like a sermon, would be by far the best section of the work. Du Noüy's exposition of the importance of human dignity is alone a justification for the existence of the volume.

Since the claim of the book is to present a hypothesis for the reconciliation of the picture of the world, as delineated by science, with the age-old intuitions of a religious nature—the "telefinalist theory of evolution" —the crucial points to be examined by a scientific reader are those mathematical, physical, and biological concepts which are the fulcra on which it revolves. These are presented in very simple and understandable style in the first seven chapters of the book. Yet the reviewer was profoundly disappointed with these concepts as outlined here. The portion on the origin

of life would appear to have been written by a mathematician who had been shut away, not only from the physical world, but from all contact with chemists and geologists, one whose only outside influence had been from the direction of highly theoretical physics. The exposition of evolution demonstrates tremendous familiarity with the facts of paleontology, combined with an incredible lack of understanding of modern concepts of the process of evolution. The point of view presented resembles those theories of evolution advocated fifty years ago by biologists, long since abandoned by them, and now retained only by those theologians who have been forced, reluctantly, to accept the doctrine of evolution. The whole modern science of evolution, so ably summarized in Julian Huxley's *Evolution, the Modern Synthesis*, has apparently had no influence whatever on the author's ideas.

An intimation of the limitations of the scientific portion of this book may be gained on page 18, where true scientific method is limited to *analysis*. If such a limitation is valid, then many scientists, including the reviewer, have been seriously exceeding their proper scope in a preoccupation with *synthesis*, held by them to be the necessary second half needed to complete the application of the scientific method.

The author brings in the laws of chance to dispose of all possibility of a natural or materialistic origin of life. His example of the black and white powders which, once mixed, will never unmix themselves no matter how long they are reagitated, would not sound so convincing had he granted the white particles the property of cohering to white particles and the black particles that of cohering to black. His whole argument, actually, is based on a universe composed of atoms and molecules with no differing properties whatever. If one grants to atoms and to the myriad of aggregations of atoms that assortment of properties which they are observed to possess, then Eddington's "anti-chance" or "cheater" may well be totally unnecessary. If this is so, then the fundamental idea on which the book is based, that of the necessity for an extra-material influence, "will," or "God" to account for the origin and evolution of life, supposedly in contradiction to the second law of thermodynamics, breaks down. It would seem, too, that the apparent conflict with this law does not really exist if life is regarded not as "an isolated material system" but as actually a part of the universe.

The author's concept of evolution as an apparently directed, but certainly not very efficiently directed, trial and error process of striving for perfection, with actual evolution restricted to the single tortuous line that finally culminated in man, would not likely coincide with that of many modern students of evolution. The now prevailing idea seems to be to regard evolution as change in the characteristics of biological populations and larger aggregations. The idea of progress is no longer regarded as synonymous with evolution, and the idea that the biological evolution of *Homo sapiens* has been completed may not find too much of a welcome. The creation or use of such words as "evolutive" may suggest that the author has wandered so far that he has lost contact with the very derivation of the word *evolution*.

The projection into the future of evolution on a "psychological plane," aided and speeded up by tradition, education, and moral effort on the part of individuals of the human race, seems a hopeless mixing of concepts. What the author has in mind is without doubt a process that actually exists, and an important one. Whether it has any connection with evolution in the biological sense may be seriously questioned.

Some psychologists may well question the duality of man, the fundamental conflict between "animal reactions" or "ancestral instincts" and "moral and psychic evolution" or "human dignity," a conflict which forms such an important part of du Noüy's ideas of evolution beyond the biological level. There would seem much more reason to believe that a balance between the two might comprise the ideal state. Undue preoccupation with either, or the election of either extreme, might be, and indeed, has been equally destructive. The idea that when a man "obeys his instincts" he "eliminates himself from evolution" is at least revealing as to the author's concept of evolution. Perhaps this evolution should be spelled with a capital E. One further wonders how, when man has reached the stage where the instinctive pleasures repel him (p. 177), the species will be reproduced.

The section on the idea of God (chap. 14) contains some very interesting psychological speculation and some theology that may well prove equally unsatisfactory to fundamentalist and to scientist. God is considered a necessity, in order that the "entire organized, living universe" be not incomprehensible. This is a very laborious justification of a belief in God. The author would, indeed, be horrified to be told that such a speculation is anthropomorphic in origin, but it is certainly that. We cannot conceive of the existence of a universe, or of anything else, without its having been created by someone or planned by an intelligence of some sort. Therefore we assume the existence of this intelligence, will, God. Regarding the origin of this God, we are now logically in exactly the same position as we were before in regard to the origin of the universe. We can perceive the universe, whereas we cannot perceive God. It is a definite strain to bring ourselves to believe in, or to accept, an intangible God, while it is no strain at all to accept the universe. It would, therefore, seem simpler to accept a universe without an obvious mode of origin than a God with the same drawback. If it were not for our background of anthropomorphic thinking, there would be no call whatever to create a God.

Du Noüy's ideas on education are perhaps among the soundest parts of his book. There is no doubt that

kind but firm discipline in the very early years of life offers a solution to many of the most difficult problems of teaching human beings to live with one another. It remains puzzling that, throughout the book, we are urged to do nothing that will weaken religion because it is needed by those who are not sufficiently intelligent or moral to get along without it, but on the other hand (p. 81), "Somehow the crowd must be made to understand that the important thing is, not to follow, but to make an individual effort. . . ." These ideas are incompatible, and one has only to travel in countries where the crowds are carefully shielded from anything that might weaken their religion to know which is the preferable course.

Though this book is by no means to be taken as expressing the modern point of view of scientists on matters of religion, nor marking a new epoch in human thought, still it is of great importance for these matters to be discussed and for all lines of reasoning to be explored. Much of a moral quality that is good is reiterated here, and the emphasis on the importance of human dignity and liberty is of tremendous value in times when both are threatened, and indeed outlawed, in large portions of the globe.

F. R. FOSBERG

SCIENCE AND FREEDOM.

By Lyman Bryson. Columbia University Press, New York. $2.75. xii + 191 pp. 1947.

The aim of the author in this essay is to "discuss the use of the scientific method in understanding human behavior and the application of scientific knowledge to the management of human affairs." Whether or not he has succeeded in his aim, he has clearly raised many fundamental questions regarding the thesis that science can be used as a tool for setting up those conditions essential to human values, and especially, to freedom. We have heard so much in recent years of the necessity of freedom for science that it is a bit startling and impressive to have the familiar thesis reversed and put in the form: Is science necessary for freedom?

By freedom, Bryson means those "social conditions in which there are enough normal choices of behavior patterns open to every person to allow for experiment, and change, and diversity, both in the successive experiences of individual persons and also among different persons in the group." Since "it is clear that men are not free to do things they have never heard of," the role of knowledge in widening freedom is also clear. Hence the importance of science, the chief human tool for enlarging the store of reliable knowledge.

Various types of society are analysed in terms of their capacity for change, and it is concluded that a "pluralistic" society, which gives greater scope and leeway for individual diversity and action, most fully makes freedom possible. Democracy can best develop in such a society, and the cost of social change is least extravagant. Education enters the scope of the analysis, for social change in such a society is largely an educational process. The teacher not only works to "maintain for this generation a part at least of what other generations have learned"; he also must assume "the purpose of criticizing culture and changing it." In the highest realm of his activity he must labor to "free as many men as possible from its [the culture's] negative compulsions." Scientific knowledge makes more certain and explicit the consequences of individual and social choices. Will increasing knowledge, then, make liberty more difficult? Not necessarily, for the possibility of freedom lies in the knowledge of consequences and the determination of action *by consent* rather than *by compulsion*.

Man lives in three environments—that of immediate experience, that of the recorded experience of all humanity, and that extended environment made possible by his instruments and symbols. Here again the relation of science to freedom is evident. The practical, absolute, and scientific patterns in which we think are natural patterns of evolutionary genesis and organic growth. "The progress of the scientific activity of men in culture . . . has been achieved by the gradual extrication of man himself from the event he is trying to control." This is the end toward which we work, "this slow process [of] the extrication of the scientific type of thinking from the others," but it raises other and grave problems as to values. What is the good society?

For this too Bryson has an answer, but we leave it to the reader, for it will be better in the original. Bryson's prose style is not easy to read—it is heavy, pregnant with thought, and often involved. But the scientist who fails to extricate from it the searching ideas that probe the relationships of science, freedom, and human culture will have missed a notable contribution to modern social and scientific philosophy.

BENTLEY GLASS

HISTORY IS ON OUR SIDE: *A Contribution to Political Religion and Scientific Faith.*

By Joseph Needham. The Macmillan Company, New York. $2.75. 226 pp. 1947.

This volume is a collection of a dozen essays, first written between 1931 and 1942, the majority of which have been previously published in some form. They deal with such apparently heterogeneous subjects as Religion and Politics, Cambridge Summer, University Democracy, Pavlov and Lenin, The Gist of Evolution, Science, Capitalism and Fascism, The Liquidation of Form and Matter, Aspects of the World Mind in Time and Space, to name a selection. "Mixed-upness," however, as the author remarks in the final essay in

the book, "may be patterned as well as chaotic" (p. 212), and the present essays are brought together out of the author's realization that the man of science, the man of history and politics, the man of religion, the man of philosophy, and indeed the so-called common man, must each converse with the others if any one is fully to comprehend or contribute to society.

Those men of religion and history and politics and philosophy, and especially that common man, will however benefit from their intercourse with the man of science only in proportion as the latter functions as a scientist in his dealings with them, applying to their problems the same powers of critical analysis, the same studied and dispassionate objectivity that he devotes to his own. Joseph Needham is a very learned man, as we all know, and his heart is warm; but he has not, in his excursions into fields other than his own, always remained as closely restrained by his evidence as when he has kept to the domains of his own laboratory.

"Water possesses a great number of unique or very unusual properties," he states in The Gist of Evolution, "... suitable for living organisms as we know them. So does carbon dioxide. Yet these substances, and all the others of which living organisms consist, existed in vast quantities prior to the appearance of life. Life, exactly as we know it, was therefore implicit in cosmic evolution. This is strong support for the marxist conception of the unity of cosmic, biological and social evolution. A cosmic teleology has thus a sound status in philosophy, while at the same time in no way interfering with causal modes of explanation in biological science" (pp. 134–135). Where are the scientist's supporting data whereby the conclusions expressed in the last three sentences are necessarily and categorically derived from the facts described in the first three? Are these not matters of conviction rather than scientific fact?

And is not the same fallacy apparent in the author's major premise, that "communism seeks the abolition of war.... Communism accepts all races and peoples in fraternal equality. These things are surely of the spirit of christianity" (p. 33). "Christianity, at least theoretically, always set a high value on individual human life.... Only communism combines and extends this christian valuation, spreading comradeship and dignity, culture and happiness in the widest possible circles to all working people, citizens some day of the World Union of Socialist Soviet Republics, where each friend will contribute all that is in him and receive all he desires. All save one thing, the domination over other friends. This the Kingdom will not permit, and its education will see to it that the desire does not arise" (p. 16).

The days are gone by when one can apply the gracious lines of Cowley, quoted by Needham in Cambridge Summer (p. 66):

> "For e'en in error such no danger is
> When join'd with so much piety as his."

Needham is speaking, clearly, of what he considers ideal communism to be, and is no idle propagandist for any contemporary local brand of it. Time may possibly prove him correct, but the event has not yet done so. In attempting to compute communism as equivalent to Christianity in its basic aim of attaining the brotherhood of man, Needham neglects the fundadamental fact that freedom is the constant that balances the equation.

JANE OPPENHEIMER

THE BIBLE IN THE AGE OF SCIENCE *Or the Correlation of Science and Religion.*

By O. E. Sanden. Moody Press, Chicago. $1.75. 141 pp. 1946.

There is undoubtedly a place for books that reconcile intelligent religious faith with the findings of science. So much the sorrier those pitiable efforts, of which the book under examination is all too typical an example! The Rev. O. E. Sanden, its author, is proud of his Phi Beta Kappa key, his membership in the A. A. A. S., and his scientific education in general. He makes a career of helping American young people straighten out their religious dilemmas by such dicta as the following:

"The works of Gregor Mendel are the best answers to Darwinistic evolution."

"The apes still hang by their tails."

"The moth that lives on the yucca flower is an example of conscious intelligence in nature."

"Osmosis is diffusion in a plant, through which particles can pass."

On the basis of scientific knowledge such as this, the author finds it quite easy to show that science supports a literal (well, a *nearly* literal) interpretation of the Bible.

Sanden's astronomy and atomic physics are no better than his biology. Even the sainted William Jennings Bryan, these twenty-two years ago, was more enlightened. Sanden's ignorance is surely surpassed only by his conceit (as to which see especially pp. 112–118).

BENTLEY GLASS

CAN SCIENCE SAVE US?

By George A. Lundberg. Longmans, Green and Company, New York, London, and Toronto. $1.75 (cloth); $1.00 (paper). vi + 122 pp. 1947.

Because "the outstanding characteristic of our time is ... confusion and contradiction in our thinking and methods of approach to human affairs," Lundberg earnestly pleads for increased support of the social sciences, which alone offer us the possibility of rational

solutions to the multiplicity of problems bedeviling society. Since "large numbers of people do not want such solutions and would be under no compulsion to accept them," he proposes that our educational procedures be revised so as to "inculcate into our population . . . a rudimentary understanding of what is the nature of scientific method as applied to human affairs . . ." The revised program should include (1) thorough training in the linguistic tools of thought, (2) familiarization with the scientific method and its range of application, and (3) establishment of a widespread appreciation and practice of the arts. With increased public approval and generous financial support, Lundberg believes that social research can yield results equal in importance to those obtained by the physical sciences, and that "only through . . . development of the social sciences can a workable world order be either constructed or administered."

The general reader may find it not impossible to agree with this much of Lundberg's thesis, or with many interesting points subsidiary to his main argument. For example, the statement "symbolic behavior and the use of symbols primarily to evoke in others the feeling and imagery experienced by oneself is the artist's main concern" is in direct line with the conclusions of at least some contemporary esthetic inquiry. Again, the author points out that the confused thinking in current discussions of "values" and their supposed incompatibility with science is the result of a semantic error which consists in converting the verb "valuating" (any selective or discriminatory behavior) into the noun "values." "We then go hunting for the *things* denoted by this noun. But there are no such things. There are only the valuating *activities* we started with, [which], like all other behavior, are to be observed, classified, interpreted, and generalized by the accepted techniques of scientific procedure."

Less satisfying is the outcome of Lundberg's wrestling with the vexed question of the role of science in directing ethical and other human behavior. Reiterating that "there is nothing in scientific work, as such, which dictates to what ends the products of science shall be used," he is able only to conclude lamely that "scientific knowledge will doubtless greatly influence . . . the wants, wishes and choices of men."

Readers of sociologist Lundberg well may wonder whether his penchant for sweeping generalization ("If scientists do not assume their proper responsibilities, charlatans will take over"), his general attitude of belligerency ("... I am here engaged in making an analysis, and its validity is in no way effected [sic] by whether anyone likes it or not") and his frequent lapses into what might be labelled bad taste in a more technical work ("... when humanists investigate sociological research ... they choose studies which lend themselves to adverse criticism. This is a favorite method among humanists, and necessarily so, since many of them cannot even read the better social science monographs") do not detract markedly from an otherwise persuasively written volume.

Lundberg's angry, sincere little book deserves wide but critical attention by the reading public. Most humanists will find it easy going.

JOHN R. GREGG

MAN AND HIS MEANING.

By J. Parton Milum. Skeffington & Son, London, New York, Melbourne, and Sydney. 15s. 125 pp. No date.

The present period is one of transition. In this respect it is unlike past ages, for every age has been a period of change. But in the past the rate of transition has generally been so slow as to be imperceptible, whereas today changes occur with such kaleidoscopic rapidity that everyone knows that the world of tomorrow will be fundamentally different from the world of yesterday.

Furthermore, man himself is taking an active part in the precipitation of these changes. Man is today shaping his own destiny on a larger scale than ever before—a destiny which approaches dangerously near to complete annihilation. Yet man neither desires annihilation nor realizes that if it comes it will be largely by his own hand. Like the lemming which plunges into the ocean to its own destruction, man is an enigma.

The work here under discussion is an attempt to answer the ancient question posed by the psalmist, "What is man, that Thou art mindful of him?" It is a scientific book, yet it is not primarily a book about science. Rather, it is a religion intended for the perusal of scientists. It is doubtful whether it will appeal to anyone who does not have a pretty thorough training in general science.

The author intends his book to be appraised and interpreted solely on its intrinsic evidence. There is nothing in either the foreword or the publisher's blurb, both of which are anonymous, that tells us anything about the author. From the title page we learn only that he is a Ph. D. from the University of London and and author of another book called *Evolution and the Spirit of Man*, and from the dedication that he had a son who taught school in Singapore and Penang and who was killed in the war.

By reading between the lines, one concludes that the iron has entered far more deeply into the soul of Britain than into our own; and that as a result the British people are now experiencing a rebirth of religious faith unlike anything on the western side of the Atlantic, and comparable only to that of seventeenth century England—and, as on that former occasion, manifesting itself chiefly not within the organized churches but in that large body of believers outside the churches, commonly called Seekers. It is the Seekers

whom the author strives to reach, or rather those of them who have had scientific training—a narrowly circumscribed audience, if an important one. His message to them is not that religion and science can be reconciled—he takes that for granted. His message is that even in a world brought to the brink of a catastrophic collapse, there is still hope that the dry bones of materialistic philosophy may again take on the living flesh of a renascent faith which will lead mankind from destruction. To one reader, at least, he has succeeded in his message.

THE PATH OF SCIENCE.

By C. E. Kenneth Mees, with the co-operation of John R. Baker. John Wiley & Sons, New York; Chapman & Hall, London. $3.00. xii + 250 pp. 1946.

The Director of Research of the Eastman Kodak Company has developed this book from the Hitchcock lectures on the development of science and its relation to the history of society, which he gave at the University of California in 1943. The result is a stimulating and thought-provoking volume, not a full history of science, but an effort to relate the history of science to the broader social history of man. Mees adopts Petrie's cyclic theory of history, a concept of civilized progress as a helical ascent, with the early coils close together, and the recent ones pulled out into an ever steeper spiral. In many respects the author's ideas coincide with those so brilliantly outlined by the late Carl Becker, in *Progress and Power*, an essay which Mees appears not to have known. Nor has Mees made an effort to relate his concept of history to Toynbee's momentous theory of the relation of civilization to the challenge of circumstances. Nevertheless, this is a highly interesting and provocative approach to the main subject of the book.

The two chapters which follow this introduction deal with the method of science and the development of the scientific method. Minor criticisms may be made here—the derivation of teleological views of science from Galen rather than from Aristotle, for example—but as a whole the account can only be praised as a superbly coherent criticism of the foundations of science. The two succeeding chapters deal with the growth of physical and chemical ideas, and following them comes a like chapter, contributed by John R. Baker, on the growth of biological ideas. Considering their brevity, these three chapters must be regarded as among the very best accounts of the history of science available.

The remaining chapters deal with the production of scientific knowledge in modern society, the most ideal organization to that end, and the relation of applied science and industrial research to the path of science as a whole. Here the author speaks from his own profound experience, and must be listened to as an outstanding authority. No stronger defense of the necessity of freedom for science and of the essential importance of basic research could be made than this which stems from a leader of applied and industrial research. The complete revolution in the author's mind as to those ideas he expressed on *The Organization of Industrial Scientific Research* in 1920 is a very weighty argument against those who would organize scientific research completely, from the top down. Now, says Mees, he holds that:

> Scientific research cannot really be organized under department leaders, who are themselves working scientists carrying out research work. The fact is that the unit of scientific research is a *scientist* with a group of assistants and he is, by definition, capable of directing his own work by his own methods. In the operation of his work, he must be independent of all control and free to do whatever he wishes. The function of his superior in the organization is not to control the operation of the work; it is to direct the work toward the problems that seem most desirable, to insure and assist co-operation between the individual research units, to provide the necessary working conditions and environment, and, in an industrial laboratory, to see that any results obtained are applied in practice. This cannot be done by a man who is himself interested in his own scientific work since he will inevitably devote himself to research on certain problems, using some members of the department as assistants and leaving the rest of the department without control. . . . The true analogy of a scientific research organization is not an army; it is an orchestra. . . . It is not the duty of the laboratory head to command his scientific staff; it is his duty to lead it.

In these days, when scientific research is more and more organized, and governmental support is more and more a necessity, the well-founded wisdom of such men as C. E. K. Mees is an invaluable asset to the progress and welfare of science.

BENTLEY GLASS

SCIENCE: *Its Effect on Industry, Politics, War, Education, Religion and Leadership.*

By D. W. Hill. Chemical Publishing Company, Brooklyn, New York. $2.75. vi + 114 pp. 1946.

This work is an interpretation of science and the relation of applied modern science to industry, politics, war, education, religion, and leadership. To the reviewer the chapter which deals with war appears to be the most timely. War has been resorted to in the past for many purposes: to increase the social prestige of a nation; to keep a tottering political party in power; to end an industrial depression. If war should become a popular panacea for all the social, political, and economic ills to which mismanaged governments are subject, cultural institutions will become its first victims, and scientific research will suffer accordingly.

The practice of commandeering in wartime the build-

ings and equipment of institutions that minister to the cultural life of the community was inaugurated by the navy during the Second World War. One trembles to think what the effect on the nation will be if this action should become established as a routine practice. But it is not inevitable that this should happen, although there is a real danger of it. The trouble has been that the scientist has not taken his responsibility as a citizen seriously enough. He realizes that the primary duty of science is not the prevention of war or any other calamity, but the pursuit of truth, whithersoever the search may lead. He has not always realized that the opportunity to be of service to his fellow men constitutes a duty to render such service, and that because he is a scientist he is frequently better qualified to do so than those in other walks of life. He has generally failed to take advantage of this opportunity, and has left the leadership in municipal and community affairs to those less well qualified intellectually to assume it. The result has too often been the mismanagement of national affairs.

The author is an Englishman who presumably has his own nation in mind, but his conclusions are equally applicable to our own. In his Foreword the author has defined science as "the power to think logically, dispassionately, impersonally, objectively, and thoroughly according to a definite pattern that can be consciously adopted and taught; to extend knowledge by ordered experiment; and perhaps one should add, *to act fearlessly on the conclusions reached.*" The italics are the reviewer's, who, while inclined to question the legitimacy of including this requirement in a definition of science, feels that this final phrase is a perfect expression of that duty which the scientist, as a citizen, owes to the community of which he is a member.

SCIENCE FOR EVERDAY USE.

By Victor C. Smith and B. B. Vance in consultation with W. R. Teeters. J. B. Lippincott Company, Chicago, Philadelphia, and New York. $2.20. xiv + 731 pp. + 6 plates; text ill. 1946.

Prepared for the one-year general science course in high schools (8th or 9th grades) or for the junior high school third-year science course (where that repeats the cycle of the first two years), this textbook is a most impressive product of care, skill, and intelligence exercised in the selection of material and its organization. Of the five major units (Matter; Energy; Life; Earth; Man), two deal wholly with biology, and some biological material is incorporated in the others, in particular a section on fossil organisms in the unit on Earth. The emphasis on fundamental biological principles is excellent: e.g., the universal characteristics of protoplasm; cellular organization; adaptation and natural selection; oxidative metabolism and energy; photosynthesis and the interdependence of life. Balance is good: energy relations, ecological relations and conservation, reproduction and heredity, variation and evolution, nutrition and excretion, health and disease are discussed simply but accurately. An abundance of experiments and demonstrations is suggested, together with study and test questions, reviews, scientific vocabulary lists, lists of scientific books suitable for reading at this level, and references to visual aids in teaching. The illustrations are abundant, well chosen, and well reproduced. Diagrams are clear. The colored plates are outstanding in attractiveness. All in all, the wonder of a college teacher of biology at the poor scientific preparation and the lack of biological knowledge demonstrated by freshmen is intensified upon examining textbooks such as this. It cannot be the fault of the school-books when such as this are available.

BENTLEY GLASS

THE WONDERWORLD OF SCIENCE. *Book Nine: Science for a Better World.*

By Morris Meister, Ralph E. Keirstead, and Lois M. Shoemaker. Illustrated by Alma Froderstrom and Thomas Voter. Charles Scribner's Sons, New York. $2.20. vi + 698 pp. + 2 plates. 1946.

Of the three ninth-grade general science textbooks reviewed here (cf. *Science for Everyday Life* and *Our World and Science*), this one has the fewest and on the whole least appealing illustrations, but the most basic approach. One would not guess this to be true from the title. Yet, while the material is organized into units that center around the concept of the social and technological functions and values of science, the actual treatment provides a consideration of fundamental concepts and principles. Thus, in the unit on matter—after an introductory story of the alchemist's efforts—the properties of matter, compounds and elements, molecules, atoms, electrons, protons, and neutrons are considered. Chemical reactions, even those involving rather complex organic molecules, are clearly and simply explained in introducing the synthesis of plastics, sulfa drugs, and alloys. Four of the ten units are devoted to biology: Plant Life, Animal Life, Man, and Health. Interesting episodes from the history of scientific discovery introduce the subdivisions, e.g., the story of Spallanzani's demonstration, by isolating a protozoan, that a single one can produce two by fission. The unit on Man is an unusual one, being devoted half to the story of human evolution, and half to a consideration of the nature and methods of science as a tool for human advancement.

Many topics that seem highly important to a biologist are, to his regret, missing altogether. Cellular organization is minimized. Human anatomy and

physiology are considered only in connection with nutrition and disease. But on the whole, what is treated is handled well.

There are suggested follow-up activities, and questions and problems of various kinds are included after each chapter. At the end are a glossary and an index. There is, unfortunately, no guide to supplementary reading for the boy or girl.

BENTLEY GLASS

OUR WORLD AND SCIENCE. *New Edition.*

By Samuel Ralph Powers, Elsie Flint Neuner, Herbert Bascom Bruner, and John Hodgdon Bradley. Ginn and Company, Boston, New York, Chicago, London, Atlanta, Dallas, Columbus, and San Francisco. $2.20. viii + 684 pp.; ill. 1946.

This is also a textbook for a full year course in general science. The authors have made it their primary aim to arouse in boys and girls a lively interest in science as the great modern adventure. They have written well, their organization is careful and clear, and the illustrations are good. There are many suggested exercises and experiments, discussion questions, and suggested books for extra reading; also a good glossary and an index. There are eight units, on the heavens, water, air, living organisms, the earth's crust, forms of energy and their applications, nutrition and health, and conservation. Biological study thus represents between one-fourth and one-third of the total, a fraction that seems rather low.

A more serious criticism is that in their stress on applications to human use, the authors tend to avoid the great principles and theories which form the real core of science, or in discussing such of them as are mentioned, to stick to generalities and applications. For example, there is no effort to define the action of gravity precisely or to deal with the structure of atoms and molecules and the nature of chemical reactivity. There is, in the realm of biology, no emphasis upon the universal aspects of life, other than "eating, self-protection, and reproduction." Protoplasm is not mentioned; cells are referred to as the units of plant and animal structure, but neither the cell nor its mitotic division are described. Mendelism is discussed without the gene (or chromosome); the discussion of sexual reproduction is limited to flowers and insects; the endocrine glands are not considered at all. Evolution is omitted altogether. It is not that such subjects cannot be taught at this level (cf. reviews of *The Wonderworld of Science* and *Science for Everyday Use*, above)—they can be and are being handled well. The decision is one of choice of material, of emphasis, and of balance. No one would contend that at this level the technological applications of science and their effects upon the life of man should remain in the background. But if the authors are sincere in their primary aim, they should remember that the great *adventure* is in basic science, not in applied; and that the understanding of scientific principles and of the way in which man has arrived at them is a crying need today. Otherwise, science and the rest of society drift apart. It is no part of education to create in the general mind a feeling of overpowering awe before the incomprehensible mysteries of science. But if, on the other hand, the fundamental understanding is established, the social and technological fruits invariably follow. To take one specific point: many of these ninth grade boys and girls will never take another science course. Most of them will become fathers and mothers and attempt some day to rear children. What more practical knowledge could they get than a clear understanding of the fundamental processes and functions of human reproduction —of cells and cell division, the formation and union of sex cells, the development of the embryo, the role of the hormones in sex, and the phases of growth, mental as well as physical?

BENTLEY GLASS

NATURE STUDY TALKS FOR YOUNGSTERS: *A Collection of Broadcast Talks.*

By Arthur J. Mee. Littlebury & Company, The Worcester Press, Worcester, England. 8s. 6d. 104 pp.; ill. 1945.

Here is a collection of talks on biology broadcast to British children by the author. Although the topics have been selected for youngsters familiar with the English landscape, they are of so general a nature and so well done as to be of equal interest even in the United States. A variety of topics are covered in accurate yet simple detail: how spiders spin their webs; the teeth of animals; the nature of rats and mice; the adaptations of animal limbs to different environments; and the problem of the extent to which plants see and feel, for example. This excellent illustrated text should be of particular value to elementary teachers because it suggests simple, easily performed experiments related to the material under discussion.

JOHN E. CUSHING

ELEMENTARY BIOLOGY IN SPRING: *March, April, May and June.*

By C. Bernard Rutley in collaboration with L. J. F. Brimble. Macmillan & Company, London. 2s. 9d. viii + 138 pp.; ill. 1946.

The appeal of this book will probably be localized in the British Isles, as the organisms it refers to are selected from this region and, therefore, vary enough in name, appearance, and occurrence to be unfamiliar to North American youngsters. The text forms part of a series

dealing with the activities of many forms of plants and animals in different seasons. On the whole, it seems to the reviewer that even English children will not be particularly stimulated to an interest in nature study through the agency of this rather heavy presentation.

JOHN E. CUSHING

PRIMEIRA REUNIÃO BIOLÓGICA PORTUGUESA. *Actas—Relatórios—Comunicações, Lisboa, 19 a 21 de Dezembro de 1945.*

Published by Sociedade Portuguesa de Biologia, Lisbon. Paper. 405 pp. + 2 plates + 1 table; ill. 1946.

These Proceedings contain, in addition to the report of the inaugural session of the annual meetings of the Society, with the address of the President and information about the organization of the Society, also a number of addresses and a considerable number of original papers. The addresses were on Karyokinesis, by F. Resende, and on Mitosis and Meiosis, by J. A. Serra; on the Biology of Immunity, by J. A. M. de Loureiro, and the Biochemistry of Immunity, by J. Toscano Rico; and on Experimental Renal Hypertension, by J. Moniz de Bettencourt. Discussions which followed these addresses are also reported. The original papers are forty in number, covering virtually all aspects of biology. Eight papers are in French, the remainder being in Portuguese.

PORTUGALIAE ACTA BIOLOGICA. *Série A—Morfologia, Fisiologia, Genética e Biologia Geral. Volume I, Numbers 1, 2, and 3. 1944, 1945, 1946.*

Edited by B. D'Oliveira, F. Resende, and J. A. Serra. Published by Instituto Botânico da Faculdade de Ciências de Lisboa, Laboratório de Patologia Vegetal "Vertssimo de Almeida," and Sociedade Portuguesa de Biologia, Lisbon.

Number 3 (1946) contains the following papers: Application de la radiation β de substances radioactives sur le cortex cérébral du chat, by S. de Carvelho; Cariological studies on the Aloinae (IV) Chromosomic set and chromatic agglutination of the species of the section Coarctatae of the genus *Haworthia*, by J. Pinto-Lopes; Unusual carotinoids in young leaves (I), by Carlos Romariz; Mitosis in the spermatogenous threads of *Chara vulgaris* L. var. *longibracteata* Kutz, by E. J. Mendes: Sur la constitution histo-chimique probable de la Olisthérozone nucléolaire, by F. Resende; Olistherochromatin in *Drosophila*, by Maria Valadares and Irene Regalheiro; On the structure of the salivary chromosomes, by Maria Valadares; Sur l'origine de nouvelles formes (II), by F. Resende and Pedro de Franca; Une nouvelle methode de coloration des nucléoles—le tannin-fer III, by M. C. de Resende-Pinto; Cariological studies on *Fritillaria lusitanica* Wickstr. (I), by Magda Botelho and E. J. Mendes; "Difference in phase" in the euchromatic cycle of chromosomes of the same karyokinetic phase, by M. Valadares and I. Regalheiro.

BIOLOGY: HISTORY AND BIOGRAPHY

FAMOUS MEN OF SCIENCE. *Third Edition.*

By Sarah K. Bolton; revised by Edward W. Sanderson. Illustrated by Constance Joan Naar. Thomas Y. Crowell Company, New York. $2.50. viii + 308 pp. 1946.

This collection of biographical essays is written in a popular, non-technical style for the benefit of the lay reader. Various fields of science are covered and include such worthies as Copernicus, Galileo, Newton, Herschel, Linnaeus, Agassiz, Faraday, Darwin, Pasteur, Kelvin, Edison, the Curies, Marconi, Reed, and Burbank. A true scientific evaluation has not been attempted, but most of the better known achievements of these men, as well as some of the more human and non-scientific aspects of their lives, are interestingly related. We disagree with the author that *Archaeopteryx* was found in England, but such errors (if there be others) do not detract from the light and pleasurable reading afforded. What will be attractive to the more professionally minded is the inclusion of some of our contemporary Nobel laureates: Einstein, the Comptons, Fleming, and Urey, whose personal habits are not so well advertised.

HENRI C. SEIBERT

MASTERWORKS OF SCIENCE. *Digests of 13 Great Classics. Masterworks Series.*

Edited by John Warren Knedler, Jr. Doubleday & Company, Garden City, New York. $4.00. x + 637 pp.; ill. 1947.

This compendium contains abridged digests of 13 great classics of science: *The Elements*, by Euclid; *On Floating Bodies, and Other Propositions*, by Archimedes; *On the Revolutions of the Heavenly Spheres*, by Nikolaus Copernicus; *Dialogues Concerning Two New Sciences*, by Galileo; *Principia*, by Isaac Newton; *The Atomic Theory*, by John Dalton; *Principles of Geology*, by Charles Lyell; *The Origin of Species*, by Charles Darwin; *Experimental Researches in Electricity*, by Michael Faraday; *Experiments in Plant-Hybridization*, by Gregor Johann Mendel; *The Periodic Law*, by Dmitri Ivanovich Mendeleyèv; *Radioactivity*, by Marie Curie; and *Relativity: The Special and General Theory*, by Albert Einstein.

In the number of selections the biological sciences are

obviously poorly represented, although probably no one will wish to quarrel with the choice of Darwin and Mendel for inclusion. A more debatable point, and one that affects all the selections equally, is that of the merit of making digests and abridgments, in general. How many young students of English and American literature have had their enthusiasm quenched rather early by being given nothing but selected excerpts for study? To what extent is the pattern of the *Reader's Digest*, so vastly popular, a deplorable one? Do we wish to encourage it in science? That this is not too serious a criticism in the present instance is to be seen from the fact that the abridgment of *The Origin of Sciences* occupies 100 pages, as against 386 in the original, and the paper by Mendel 24 pages, against 45 in the original.

Each selection has an Introduction of two or three pages on the life of the scientist represented and a bibliography of his principal works. There is also a General Introduction, but no index. The volume is handsomely bound and well printed.

BENTLEY GLASS

HENRY SEWALL: *Physiologist and Physician.*

By Gerald B. Webb and Desmond Powell. The Johns Hopkins Press, Baltimore. $2.75. x + 191 pp. + 10 plates. 1946.

Clio is probably the most capricious of the Muses. There have been geniuses of every calling who have taken their turn in bending her to their will; but with others, who are merely great men, she is often whimsical in her choosiness. Henry Sewall she has hitherto largely ignored, and this biography has been written with the aim of attempting to persuade her to reconsider her judgment.

Henry Sewall was descended, on his paternal side, from a family whose members have distinguished the various professions in New England since early colonial days. His life, together with his professional accomplishments, forms an interesting bridge between the old and the new in American medicine. Born in Baltimore in 1855, he was the first student to register for the B.S. degree at Wesleyan. Unable to fulfil his original intention of entering Harvard Medical School because of financial difficulties, he entered The Johns Hopkins University in 1876, the year of its foundation, as a graduate student. Through an introduction by Dr. James Carey Thomas, he became a student and assistant of Henry Newell Martin, who was the inspiration of so many of the greatest of American biologists—indeed, the Biology Department in Sewall's day included, besides Martin, also E. B. Wilson and W. K. Brooks, who with Martin were the greatest giants, in their influence, of all American biologists. After receiving his Ph.D. degree at Hopkins in 1879, Sewall studied abroad with Carl Ludwig, with Willy Kühne, and with Sir Michael Foster.

His training bore full fruit, and he attained considerable eminence in his own right. He was Professor of Physiology at the University of Michigan from 1882 to 1889, Resident Physician at Saranac from 1889 to 1890 (having received his M.D. degree from the University of Denver in 1889), Professor of Physiology at the University of Denver from 1890 to 1908, and from 1911 to 1918 Professor of Medicine in the University of Colorado Medical School. He made many contributions to the practice and to the literature of medicine until his death in 1936.

His most significant special contributions were probably the demonstrations that a stimulus too mild to cause a reaction may modify succeeding reactions, that the chief cells of the gastric glands are the source of pepsin (with J. N. Langley), the demonstration of the role of the depressor nerve (with D. W. Steiner), and the demonstration that pigeons can be immunized against the toxic action of rattlesnake venom by inoculation with gradually increasing sublethal doses of the venom. In his latter years he specialized on the study of tuberculosis, from which he himself suffered.

His wider contributions were the influences he exerted on his friends, his students, and his patients throughout his career. This is a fine biography of a fine man, who exemplified in his professional accomplishments, in his character and in his relationships with his friends all that is best in the American medical tradition, and the American reader and Clio will do well to give this biography and its subject the attention they deserve.

JANE OPPENHEIMER

THE WORLD EXPANDS: *Recollections of a Zoologist.*

By George Howard Parker. Harvard University Press, Cambridge. $4.00. x + 252 pp. + 1 plate. 1946.

"Chatty reminiscence" is the phrase that best characterizes this book. G. H. Parker has told in a clear, straightforward style the story of his education, his travels abroad, his romance and marriage, his university life, and his recreations. Touches of humor brighten the pages, but a great deal of detail has been included that will interest only a small circle of the author's immediate friends and relatives. Parker's experiences abroad and the inside story of the development of zoology at Harvard University will perhaps have widest appeal. (It must be said, as to the former that G. H. Parker is not the most trustworthy guide to the Orient—his childhood difficulties with English spelling reerupted in his struggle with Chinese and Japanese place-names. Most startling was the evident transformation of "Chefoo" into "Foochow," producing a slight error of a few thousand miles.)

Biologists who pick up this book hoping to find a full account of G. H. Parker's researches on the evolution of the nervous system and on pigment cells and neurohu-

mors will be doomed to disappointment. The author has been altogether too modest in this respect; although, of course, his researches have not been completely ignored—roughly about one chapter (parts of several) out of twenty-four being devoted to them. Surely the paramount interest for readers of a scientist's life lies in the work itself which he has accomplished, and the development of his life around it. Parker has written a book that may be likened to one of those agreeable comedies which lack a plot.

BENTLEY GLASS

DANIEL COIT GILMAN: *Creator of the American Type of University.*

By Abraham Flexner. Harcourt, Brace and Company, New York. $2.00. xiv + 173 pp. + 3 plates. 1946.

The story of the founding of the Johns Hopkins University and the unfolding of its early educational program has been told repeatedly, but never with that masterly touch which Abraham Flexner achieves in his life of Daniel Coit Gilman. It is a wonderfully compact little book, well printed, easy to handle, crystal clear, and full of distilled wisdom. Every paragraph, every sentence is fraught with meaning; every word has a necessary place. It has no air of pretension. There is no padding. It might well serve as a model in the art of exposition. It starts out to be a biography of the first president of Hopkins, but as it narrates his career it becomes the exposition of a way of education.

In the 1870's research and investigation were new words among American educators. These words were always on Gilman's tongue as he fought for the establishment of graduate education in the United States with the three millions and a half Johns Hopkins had left, with no strings attached, to found a University. Discarding the sentimental dream of students under the oaks at Clifton, which is said to have been Johns Hopkins' own desire, Gilman invested in scholars instead of elaborate buildings. Men were needed, the right men, whether they were young or old, whether one hundred per cent American or born overseas, men with a passion for pushing forward the frontiers of knowledge and for training their successors. In the glorious academic procession of the past we see the men Gilman secured—Gildersleeve, professor of Greek; Rowland, the physicist; Sylvester, famous mathematician, an Englishman of 62 when called to Baltimore; Ira Remsen, chemist, later to become Gilman's successor; Morris, the classicist; Newell Martin, another Englishman, only 28 when made professor of biology. To the medical school, of later foundation, came other distinguished leaders, great doctors and great teachers. Sargent painted the Big Four: Osler, Halsted, Kelly, and Welch. In physiology and anatomy Howell and Mall stimulated many young men to undertake careers of teaching and research. The Hopkins leaven was spread throughout the country by the students of this varied group and by their students' students.

Abraham Flexner himself is a product of the Gilman regime. His whole life has been spent in the cause of education. His report on conditions in the medical schools of the United States and Canada, which he surveyed for the Carnegie Foundation for the Advancement of Teaching, led to his appointment to the General Education Board. Financed by John D. Rockefeller, this body of men undertook a thoroughgoing reform and reorganization of medical education in this country. Abraham Flexner's advice was sought at every step. Finally, as director for many years of the Institute for Advanced Studies at Princeton, Flexner took a leading part, deservedly, in the permanent establishment of an institution where ideas might be pursued and flourish without pressure of college enterprise.

Abraham Flexner has not written a book of reminiscences about the "good old days" at Hopkins. He has prepared his study of Daniel Coit Gilman with the zeal of a crusader. Education is admittedly at the crossroads since World War II. Changes and reorganization are necessary in the universities. Flexner asks college presidents and faculty committees to pause and study "what Gilman did and why he did it."

BETSY C. CORNER

A HISTORY OF THE UNIVERSITY FOUNDED BY JOHNS HOPKINS.

By John C. French. The Johns Hopkins Press, Baltimore; Humphrey Milford, Oxford University Press, London. $4.75. xii + 492 pp. + 27 plates. 1946.

John C. French's long and careful history of the Johns Hopkins University is primarily the story of the university as an organization. Although here and there the author has something to say about the personalities of prominent teachers and executives, and about the academic atmosphere (strangely different, in the earlier days at least, from that of all the other American universities) still his story is chiefly of plans and curricula, of methods of teaching, of the University's interrelations with City and State, the ups and downs of finance, and even the fluctuating careers of undergraduate journals and college dramatic clubs. As such, the book becomes a document in the history of institutional education, and will be instructive not only to Johns Hopkins alumni, but to all who want to understand how this particular university made its peculiar kind of success, what it was able to do for the nation, in what respects it has failed, and what are its present assets of tradition, equipment, and hopes. The great achievements of the Johns Hopkins—the development of postgraduate studies and the advancement of medical

education—have been told before, but there were many other valuable contributions to American university organization, as can be learned from this book. At the present time, for example, when the pendulum is everywhere swinging from the elective system too far toward curricular rigidity, faculties ought to be reminded of the group system of studies, by which Gilman and his staff long ago worked out a sensible middle course. The ingenious planning and operation of the library, by which it serves at once the needs of intensive students and of a large body of general readers, is another such item. So too is the decent and healthy solution of the problem of college athletics.

The collegiate part of the Hopkins always was and still is a good place for a young man who wants to get an honest college education and put himself in touch with advanced scholarship, but it has often been decried or suspected, for one reason or another. At first it was called by its critics a trivial appendage to a great graduate school, and on the other hand, after the move to Homewood, the administration has been accused of overdoing the collegiate side. Abraham Flexner's life of the first President, Gilman, reviewed elsewhere in this number of the *Quarterly Review of Biology*, is inferentially such an accusation. Gilman, it is hinted, would not have let the college outgrow the professional schools. Between the lines of French's history one senses a reply to this charge, and in fact the book explicitly claims that the college was a particular concern of President Gilman's.

Readers interested in biology will find the history of that subject at Johns Hopkins only sketchily outlined. The author indeed disclaims any hope of doing justice to the achievements of individual departments. Some interesting developments, now outmoded, are mentioned—for instance, the Naturalists' Field Club and the old Chesapeake Biological Laboratory. A nonexistent "Professor Newell" (i.e., H. Newell Martin) is mentioned once or twice in the text, although not in the index. The history of the Medical School is more fully treated. It seems a pity that the name of the third Dean, Lewis H. Weed, is not mentioned, not even in the passage (p. 419) that describes the great increase of endowments and buildings made during his incumbency.

This book, judicious, loyal, and dryly humorous like its author, is if anything too modest and defensive. It does not blow the trumpet even when there is something to blow about. Two great things can be said of the Johns Hopkins University. The first is that it has always aimed to put scholarship first. Readers of John C. French's history will not miss that fact, but the other is not so explicitly claimed (except in a quotation from Gildersleeve) and may be lost sight of amid all the details here assembled. It is that the Johns Hopkins University has lived up to its motto. Nowhere is there a place where scholars have been more free. Liberty of thought is now threatened everywhere. University men cannot remind themselves too often that freedom must be guarded, above all, on the campus.

GEORGE W. CORNER

VICTORY OVER PAIN: *A History of Anesthesia.* *By Victor Robinson. Henry Schuman, New York.* $3.50. xiv + 338 pp. + 30 plates; text ill. 1946.

This history of anesthesia, appearing on the occasion of the centenary celebration of the anesthetic ether, takes its place beside a number of similar treatises this year. The book appears to have little to distinguish it from these other contemporary volumes. The first six chapters are devoted largely to the very early use of pain-relieving herbs. These appear as repetitious historical material to the average medically-trained reader.

The chapters on Sir Humphry Davy and the role of Henry Hickman in the development of gaseous anesthesia make the book a valuable contribution to the history of anesthesia. Five chapters are devoted to Long, Wells, Jackson, and Morton, and the ether controversy. An unusual and interesting approach to the subject matter is presented by the author in the succeeding four chapters entitled: The Reception of the Discovery in Europe. These chapters broaden one's viewpoint on the discovery of anesthesia. Contributions of the famous Nicoli Ivanovich Pirogoff to the "Great Discovery" are described. His development of the concept of rectal administration of ether vapors is especially interesting.

The classic literature on the development and acceptance of the relief of pain by chemical agents is adequately discussed in the following chapters on the history of the discovery of chloroform anesthesia. Two chapters are devoted to local anesthesia and the work of Richardson and Koller.

The succeeding sections of the book deal with the history of the development of the technic of the administration of anesthetics. Here one is puzzled by the author's approach to the subject. Details of complicated apparatus and technics of administration are described. Admittedly this is very interesting to the technically trained anesthesiologist, but it must appear bewildering indeed to a lay reader.

The book is a comprehensive account of the story of anesthesia, and the physician and biologist may welcome this volume into his library.

JOHN C. KRANTZ, JR.

HISTORY OF MEDICAL THOUGHT: *An Essay.* *By Richard A. Leonardo. Froben Press, New York.* $2.00. 94 pp. + 16 plates. 1946.

In ninety-two pages, a history of philosophy and medicine from prehistoric times to our own day! It would take many more pages to correct the half-truths and outright errors that occur on every page of this essay. The understanding of the subject and the ability to present it are on the same level as the factual accuracy.

ERWIN H. ACKERKNECHT

ECOLOGY

THE HOT SPRINGS OF ICELAND: *Their Animal Communities and their Zoogeographical Significance. The Zoology of Iceland, Volume I, Part 11.*

By S. L. Tuxen. Ejnar Munksgaard, Copenhagen and Reykjavik. Kr. 15.00 (paper). 207 pp. + 7 plates + 2 charts; text ill. 1944.

The scope of this publication is much wider than its title would indicate, as the author has included a discussion of several very general matters in relation to hot springs and their fauna. These include lists of those animals, mainly arthropods and especially insects, reported from hot springs in all parts of the world, as well as the grouping of thermal waters on the basis of temperature, chemical constitution, and physical factors.

The author has studied the Icelandic springs in great detail, and a tabulation of the extensive collections he has made forms the major part of the paper, together with an elaborate account of the bionomics and development of *Scatella thermarum*, an ephydrid fly. There is also a very complete account of the microfauna of the soil about the hot springs, particularly of the mites and Collembola. Finally, there is a portion which deals with life and hot springs during the ice age. There are several well selected series of bibliographical references to all phases of hot springs biology.

Altogether, this is an important contribution to a knowledge of the fauna of hot springs and to the ecological relations of thermophilous animals. A previous statement of the author that the larvae of *Scatella* live in water at 65°C. is shown to be erroneous, as the temperature resistance of the larvae of this fly does not depart from the maximum observed for other forms of animal life, never exceeding about 50°C.

The text is in English, and the fluent use of our language by Tuxen is a noteworthy feature of his writing.

C. T. BRUES

WONDERS OF THE GREAT BARRIER REEF.

By T. C. Roughley. Charles Scribner's Sons, New York. $5.00. xvi + 282 pp. + 51 plates. 1947.

This book, which has been in print in Australia for ten years, is now presented in this American trade edition. It is printed from the same plates, so that pagination and format are identical. There have been three books about Australia's Great Barrier Reef, but the others, by Saville-Kent and C. M. Yonge, have long been out of print, and this one, with its wealth of detailed information on the fauna, ecology, and fisheries resources of the region, will fill a long-felt need of American biologists and curious readers for a general work on the reef. The author is now superintendent of Fisheries of New South Wales, and was formerly president of the Royal Zoological Society of New South Wales. He knows the great barrier reef probably better than any other man, except possibly C. M. Yonge. The book's illustrations are excellent; colors are, on the whole, well reproduced and seem to be somewhat better than in the Australian edition. One misses, however, a bibliography.

JOEL W. HEDGPETH

THEY LIVE IN THE SEA.

By Douglas P. Wilson. Collins, London. 12s. 6d. 128 pp.; ill. 1947.

This book differs from the author's previous one, *Life of the Shore and Shallow Sea*, in that it is mainly a series of excellent photographs of the various littoral invertebrates and fishes of the Plymouth area, with an accompanying text, rather than a discussion of the basic principles of marine biology. Thus it falls into the class of popular seashore books—but at the same time it is easily the best such book now in print. The author is an able and painstaking photographer as well as a highly competent naturalist, and it is hard to decide whether text or photographs are the better part of this book. His advice to amateur naturalists is worthy to be received of all men: "... it is far better for anyone who is merely interested in the wonderful and varied forms of living things to be seen between tide marks to seek them out and to watch, and then to leave them behind in their natural haunts. There is much to be seen and learnt by quietly watching by the side of a rock pool, or by taking note of the way in which the different species are distributed over the shore.... The amateur marine naturalist can enjoy to the full many hours on the shore without ever needing to take away with him the animals he has observed. To destroy without need is to waste" (p. 44).

JOEL W. HEDGPETH

WHO AM I?

By Lily Swann Saarinen. Reynal & Hitchcock, New York. $1.50. 30 pp.; ill. 1946.

Who Am I is a child's storybook parade of animals as they live in, and are adapted to, their varying habitats, climaxed by the portrait of a small boy who obviously

is set apart from all other members of the animal kingdom by virtue of his inherent mental and physical characteristics. The text is well done; but the implications are such that, even to a child, a feeling of superiority and condescension would be engendered in place of a sympathetic and objective understanding of the biological world which surrounds us, a feeling which is all the more dangerous since its basis is not biologically sound.

EVOLUTION

DATING THE PAST: *An Introduction to Geochronology. By Frederick E. Zeuner. Methuen & Company, London.* 30s. xviii + 444 pp., 24 plates + 2 charts; text ill. 1946.

This extremely important work represents a pioneering attempt at the development of time scales extending back beyond the historical calendar. At present, the chief application of such scales relates to prehistoric archeology and human paleontology. Hence this book deals largely with these fields and will consequently prove of especial interest to students of man's cultural and physical evolution. Its scope extends so far beyond these special fields, however, that it will undoubtedly also prove of the greatest interest and importance to all paleontologists, to geologists, and to biologists as well. It is impossible in a brief review to give an adequate picture of the wealth of detail and close documentation of this scholarly treatise. It is easy to understand how its preparation occupied the best part of seven years.

Four methods of dating are described at great length: (1) dendrochronology or tree-ring analysis, which relies on cycles of the year and of sunspots, and which carries back to about 1000 B.C.; (2) varved clay analysis, relying on cycles of the year, of sunspots, and on the precession of the equinoxes, covering the last 15,000 years; (3) the solar radiation method, based on equinoctial precession, the obliquity of the ecliptic, and the eccentricity of the earth's orbit, embracing about 1 million years; and (4) the radioactivity method, depending on the decomposition rates of radioactive minerals, and extending over some 1,500 million years.

A closing chapter, of particular interest to biologists, deals with biological evolution and time. As an application of the methods outlined above, the approximate minimum absolute ages of some animal groups have been assessed. Thus, for example, scorpions are estimated as having existed for about 390 million years, cockroaches 240 million, bony fishes 300 million, amphibians 285 million, reptiles 270 million, birds 120 million, mammals 160 million, man-like apes 50 million, and man 1 million.

Zeuner is impressed by the "explosive" nature of evolution, i.e., the more or less simultaneous appearance of major systematic groups. These explosive episodes he estimates as having lasted for several tens of millions of years and as having resulted in a logarithmic increase in the number of species and genera (the production-rate of new types exceeding the extinction-rate). He regards the computed rate of species-production as surprisingly low, probably of the order of two new surviving species in 5 million years—the fastest known time-rate of species-evolution being approximately 500,000 years. The number of generations appears to be of less significance than the absolute time. Every species is regarded as having passed through an episode of rapid evolution before it became stabilized, and every higher category through a similar but still longer, "jerky" episode. In consequence of the above thesis, Zeuner is led to conclusions that most geneticists will undoubtedly regard as unorthodox. He follows Goldschmidt in rejecting "micromutation" as a major evolutionary factor, stresses the importance of "aromorphosis" as advanced by Sewertzoff, and feels it necessary to consider seriously that characters acquired in response to environment or habit become heritable over periods of time too long to be susceptible of experimental verification. In this connection, especially, it is to be regretted that he did not consider G. G. Simpson's *Tempo and Mode in Evolution* (1944) in other than a brief, appended footnote—an omission due, no doubt, to the difficulties imposed upon scientific intercourse by the war.

WILLIAM L. STRAUS, JR.

ON THE EVOLUTIONARY SIGNIFICANCE OF THE PYCNOGONIDA. *Smithsonian Miscellaneous Collections, Volume 106, Number 18. Publication 3866. By Joel W. Hedgpeth. Smithsonian Institution, Washington, D. C.* 50 cents (paper). ii + 53 pp. + 1 plate; text ill. 1947.

The contents of this article are somewhat broader than the title implies, as much general information about the pycnogonids has been furnished. The pycnogonids are a class of arthropods that have no evident relationship to any other arthropod group, but within themselves are so similarly constructed that a division into categories higher than families appears unjustifiable. A synopsis of the families and family characters is given. Much of the article is devoted to a consideration of the ten-legged forms, which pose an evolutionary problem, as they are very similar to normal eight-legged genera. Yet the phenomenon of a very unified arthropod group that presents some genera differing in number of segments and pairs of appendages from the other members is unique. After pointing out in detail the striking correspondence between the ten-legged and certain eight-legged species, the author comes to the conclusion that the ten- (or twelve-) legged condition is a case of polyploidy, but evidence for this

theory must await examination of the chromosomes. The fact that the extra-legged forms are limited to the Antarctic and to tropical America suggests temperature extremes as causative factors of polyploidy. The article closes with a discussion of their geographic distribution. Dispersal by means of the floating Sargassum probably accounts for the distribution of species along both sides of the Atlantic. There are no bipolar species. There is greater endemicity and wider distribution in the southern than in the northern hemisphere. The author is to be commended for having provided an interesting and informative account of a little known group.

L. H. HYMAN

FOSSIL VERTEBRATES FROM WESTERN NORTH AMERICA AND MEXICO. *Contributions to Paleontology. Carnegie Institution of Washington Publication 551.*

By E. L. Furlong, E. Raymond Hall, Lore Rose David, Robert E. Wallace, and Hildegarde Howard. Carnegie Institution of Washington, Washington, D. C. $3.00 (cloth); $2.50 (paper). iv + 195 pp. + 31 plates; text ill. 1946.

This is a further addition to the valuable series of contributions to the paleontology of the West supported by the Carnegie Institution and begun under the leadership of the late J. C. Merriam. The volume of about 200 pages contains eight papers devoted to vertebrates —mammals, birds, fishes.

E. L. Furlong contributes two papers on the "antelopes," a group in which he is particularly interested. Abundant remains from the San Josecito cave in Mexico, collected by Stock, have furnished for the first time adequate material for a complete restoration of the skeleton of the four-horned Pleistocene antilocaprid *Tetrameryx*, and for a study of horn growth. A restudy of the remains of the diminutive antelope from the La Brea tar pits indicates that (as Stirton suggested) this form does not belong to the genus *Capromeryx* (of which the type is from the late Tertiary of Nebraska), but represents a new genus, *Breameryx*, characteristic of the Pleistocene of the Southwest.

Fossil badger material is rare and generally fragmentary in nature. E. R. Hall here describes the best American specimen, a skull from the Pliocene of Oregon. As a result, he establishes the new genus *Pliotaxidea* for the ancestors of the American badgers, already distinct in the late Tertiary from their Eurasian relatives, and follows this with an analysis of badger adaptations and the zoogeographic history of the larger mustelids.

A final mammal paper is that by R. E. Wallace, describing a newly discovered mammalian fauna from Beatty Buttes, Oregon. The material, although fragmentary, includes some 20 forms; the age is Barstovian (late Miocene).

Fossil Lake, Oregon, has long been famous, through the work of Cope and Shufeldt, as the site of one of the most important deposits of Pleistocene bird bones in the country. The study of a new collection from this locality has led Hildegarde Howard to a review of the entire Fossil Lake material, since previous lists showed obvious inaccuracies—a situation due in part (as Howard suggests) to the lack of adequate comparative material in earlier times, in part (as she modestly omits to state) because earlier workers lacked her own broad knowledge of Pleistocene bird faunas. As a result of her studies numerous changes are to be made in the faunal list. Some 70 forms are present. The avifauna was in general much like that living today about inland lakes in Oregon or California, but about a quarter of the species are now extinct.

Lore David contributes three papers on fossil fishes. The first points out, with practical examples, the potential value in stratigraphic studies of teleost fish scales, abundant in various Tertiary deposits in California, as elsewhere. A second paper continues this theme in a study of a fish fauna which mainly consists of scales found in well cores from the late Eocene and Oligocene of the Kreyenhagen formation in the San Joaquin Valley; the third describes a fauna based on similar material from Upper Cretaceous cores in the same valley. In both these papers a considerable number of new genera and new species of teleosts are described with confidence from scale material. The faunas permit an analysis of the bathymetric and climatic conditions under which the deposits were formed.

Much of the existing literature on American fossil teleosts is inadequate in nature and of dubious value; restudy is badly needed. Competent workers are rare and it is to be hoped that aid may be forthcoming for a continuation of David's useful studies.

A. S. ROMER

EVOLUTION AND THE BIBLE.

By James A. Becker. DeVorss & Company, Los Angeles. $3.00. 231 pp. 1946.

Echoes of the Scopes trial in 1925 reach today's younger generation of scientists and students only through Frederick Lewis Allen's brilliant reminiscences of it (*Only Yesterday*) or in such an occasional book as this one by the Rev. James A. Becker. Yet throughout vast reaches of the United States the battle for the freedom to teach scientific truth is yet to be fought to a successful conclusion. A survey of U. S. high schools in 1942 showed that organic evolution is still an avoided subject in at least half, and probably considerably more than half, of the high schools of our country. It is therefore reason for encouragement to pick up such a book as this by the Rev. Becker.

The author is no scientist and makes no pretense of

being one. He is a Protestant minister whose intelligence was revolted at the ridiculous figure cut by religious fundamentalism at the Scopes trial, and who forged for himself a stronger faith by turning the light of critical study and unbiased judgment upon his beliefs. To his mind, as earlier to that of Henry Drummond, the evolution of the Bible itself and of religious, moral, and ethical beliefs through the centuries found origin and substantiation in the greater trend of organic evolution. And if his views of evolutionary processes seem naive or antiquated, or occasionally quite mistaken, one must often credit it to too great a reliance upon such scientists as Henry Fairfield Osborn and Alexis Carrel, who might be judged more harshly because of their greater light. What is profoundly impressive in this book, apart from its firm spiritual quality, is the liberal openmindedness, the inquiring, testing character that possesses the author. His knowledge of biology cannot be recommended as a guide to others; but the United States needs more Christian ministers of such insight and intelligent faith.

BENTLEY GLASS

THE GIANT OF THE SIERRAS.

By Emerson Hartman. Chapman & Grimes, Boston. $2.00. 158 pp. + 4 plates. 1945.

It would seem that the Deluge Geological Society, which publishes the *Bulletin of Deluge Geology and Related Sciences*, has incubated and hatched out this extraordinary chick. "While primarily written as entertainment," says the publisher's blurb, "the book discloses a background of extensive study in geology, anthropology, history, and biblical profundities." These are in the form of footnotes, which the children who read the story with eyes agog will presumably skip. It all adds up to pterosaurs, dinosaurs, mastodons, apemen, human giants, and civilized men (including Noah) cavorting enthusiastically in company in the days before the Great Deluge, of 4,293 B.C., to be precise. A photograph of the giant man's knee and toe bones is shown opposite p. 50, and another, of one of his unfortunately nearly obliterated footprints upon a rock (igneous), opposite p. 98. Opposite p. 150 is documentary evidence of human and dinosaur footprints occurring side by side in the same rock. "Nunc dimittis. . . ."

BENTLEY GLASS

EVOLUTION: *International Journal of Organic Evolution. Volume I, Nos. 1–2. March–June, 1947.*

Edited by Ernst Mayr. Published by the Society for the Study of Evolution, c/o Karl P. Schmidt, Chicago Natural History Museum, Chicago 5; Lancaster, Pa. $6.00 per volume; $1.50, single issue. Published quarterly.

This journal has been established as the organ of the Society for the Study of Evolution, in order to gather and focus the contributions of geneticists, taxonomists, and paleontologists within the rapidly developing field of experimental evolution. "Contributions from all fields of biology are invited provided that the facts and conclusions presented are of prime interest to the student of evolution." A grant from the American Philosophical Society has made possible the founding of the journal.

The first issue contains the following articles: Adaptive Changes Induced by Natural Selection in Wild Populations of *Drosophila* (Th. Dobzhansky); Sexual Behavior and Isolation in Drosophila I. The Mating Behavior of Species of the *Willistoni* Group (H. Spieth); Observations on Evolutionary Rates in Hypsodonty (R. A. Stirton); Second Chromosome Inversions in Wild Populations of *Drosophila melanogaster* (P. T. Ives); A Comparative Analysis of the Chromosomes of the *guarani* group of *Drosophila* (J. C. King); Ecology and the Evolution of Some Hawaiian Birds (D. Amadon); Natural Hybridization of *Salvia apiana* and *S. mellifera* (C. Epling); Hybridization in a Population of *Quercus marilandica* and *Quercus ilicifolia* (G. L. Stebbins, Jr., E. G. Matzke, and C. Epling); Experimental Studies on Adaptive Evolution in *Gasterosteus aculeatus* L. (M. J. Heuts); Genetic Drift in a Population of *Drosophila immigrans* (W. P. Spencer); Notes and Comment.

The printing (double column) is good, but the paper is rather yellow and not of top quality. This seems especially unfortunate because the halftones are printed on regular stock, a practice which cannot be commended.

GENETICS AND CYTOLOGY

ACTIONS OF RADIATIONS ON LIVING CELLS.

By D. E. Lea. Cambridge, at the University Press; The Macmillan Company, New York. $4.50. xii + 402 pp. + 4 plates; text ill. 1947.

The extensive use of ionizing and ultraviolet radiations as tools in the experimental resolution of fundamental biological problems recommends that some effort be made from time to time to appraise and integrate the various findings. This is an assignment of considerable magnitude and responsibility, requiring a breadth of vision capable of assessing objectively the important contributions of physicists and biologists. The task has been undertaken by the late D. E. Lea and the results presented in a book which is written "for medical, genetical, and biological investigators, and for physicists interested in biology." It should prove extremely use-

ful as textbook and reference, and an invaluable guide for all students of radiation biology.

An introductory chapter deals briefly with the physical properties of ionizing radiations. Extensive data concerning the dissipation of energy in tissues by different kinds of radiation are provided in this section—and in an appendix—by a series of specially computed tables. These tables, and others relating to various aspects of quantitative studies of the action of radiation, represent a notable contribution, designed "to enable the experimentalist to interpret his results along the lines suggested without any technical mathematical ability being required."

In the second chapter, the chemical effects of ionizing radiations are described. The discussion focuses thereafter on the extensive experimental data that have been amassed concerning the biological effects of radiations. No attempt has been made to survey the whole field, but rather to give a "detailed discussion of the mechanism of those actions of radiation which are sufficiently well understood for such a treatment to be profitable at the present time." The topics discussed include the inhibition of mitosis, the nature and mechanism of induction of gene and chromosome changes, the inactivation of viruses, and the production of lethal effects in bacteria and cells of higher organisms.

Through an analysis of the experimental evidence that has been contributed in the study of these diverse topics, some broad conclusions have been drawn and general theories advanced. In appraising their merits, it is necessary to keep in mind that the basic data involved are not always in agreement, and that Lea's choice between opposing views, which is influenced by his own experimental experience, is not always shared by other workers. For example, an analysis of the *Drosophila* data appears to Lea to provide "a consistent picture of the production of recessive lethals"; but Fano, in a recent note in *Science*, has pointed out some specific objections to this evaluation. To the reviewer it appears also that preliminary quantitative estimates are at times presented in this book in such precise terms that they bear the semblance of rigid finality. Thus, in evaluating the statement, "The experimental result is that 3000 r. produce in 1000 *X* chromosomes 87 lethals, of which 39 are type A, 18 are type B, and 30 are type C," the reader will need to consult the original reference, indicated in a footnote, to find that an experimentally derived datum used in these calculations involved analysis of only 19 lethals.

It is thus apparent that some caution must be exercised in accepting the broader implications of those general theories which, at the present level of our knowledge, serve best as working models for further investigations. Much remains to be determined concerning the precise sequence of events that transpires in living cells between irradiation and the production of a detectable change. Additional information is being sought not only by the application of a wider array of physical agents, but also by the utilization of methods capable of modifying the responsive capacity of the living system to radiation. Induction by chemicals of changes in the germinal material similar to those induced by ionizing radiations also promises to provide important clues to an understanding of the fundamental mechanisms involved. Contributions along these lines have been accumulating in the three years since Lea's book was prepared for publication (the preface is dated July 1944, and the only bibliographic references beyond that year are four 1945 papers of Lea and Catcheside); as they increase in number, a reevaluation of many aspects of the work may be required. It is to be regretted that Lea's recent accidental death throws this task into other hands; but the monumental work represented in the book he has completed will serve as an invaluable guide and pattern for further efforts.

BERWIND P. KAUFMANN

HEREDITY AND VARIATION IN MICROORGANISMS. *Cold Spring Harbor Symposia on Quantitative Biology, Volume XI.*

[*Edited by M. Demerec.*] *The Biological Laboratory, Cold Spring Harbor, L. I., New York.* xii + 314 pp. + 14 plates; ill. 1946.

This symposium marks the welcome resumption, after a regrettable lapse of three years caused by the war, of the *Symposia on Quantitative Biology*. Appropriately, the topic of the current symposium belongs to that field of biology which probably developed most rapidly during the war. The papers were grouped under four headings for presentation at the symposium. The first group was comprised of papers dealing with viruses. A. D. Hershey, and M. Delbruck and W. T. Bailey discussed mutations in viruses, the former spontaneous mutations, and the two latter, in a joint paper, induced mutations. N. W. Pirie discussed the state of the virus in the infected cell, while Thomas F. Anderson presented a paper concerned with morphological and chemical relations in viruses and bacteriophages.

The second group of papers consisted of those dealing with bacteria. C. B. Van Niel discussed the classification of bacteria. René J. Dubos' paper was concerned with variations in antigenic properties in bacteria. Mary I. Bunting reviewed the data on the inheritance of color in bacteria. Maclyn McCarty (and co-workers) discussed the biochemistry of induced transformations of pneumococcal types. André Lwoff discussed problems concerned with spontaneous biochemical mutations; and E. L. Tatum discussed induced biochemical mutations in bacteria. S. E. Luria reviewed data concerning spontaneous mutations to resistant forms; and M. Demerec and R. Laterjet discussed bacterial mutation to resistant forms, induced by

radiations. The preceding papers were originally scheduled as part of the symposium. As the result of discussions during the symposium, three papers were added: one by Louis Dienes on reproductive processes in bacteria; a second by Joshua Lederberg and E. L. Tatum on the occurrence of prototrophs in mixed cultures of bacteria of which the original members were not prototrophs; and a paper by Arthur Shapiro on the kinetics of growth and mutation in bacteria.

The third group of papers dealt with fungi, yeasts, and protozoa. T. Johnson discussed inheritance in rust fungi. G. Pontecorvo presented data on genetic systems based on heterocaryosis. David Bonner discussed biochemical mutations in *Neurospora*; and Francis J. Ryan reviewed the problem of back-mutation and the adaptation of nutritional mutants in the same organism. S. Spiegelman discussed nuclear and cytoplasmic factors controlling the enzymatic constitution of yeasts; and Carl C. and Gertrude Lindegren discussed a similar problem and in addition presented data on the cytology of the yeast cell. A. Hollaender and C. W. Emmons discussed induced mutations in fungi. And T. M. Sonneborn discussed cytoplasmic genetic factors in *Paramecium*.

The fourth group of papers consisted of papers by John G. Kidd on the distinctive constituents of tumor cells, by E. C. MacDowell on leukemic cells in mice, by M. M. Rhoades on plastid mutations, and by Oscar W. Richards on the phase microscope. In addition to the above papers an appendix presents a proposed "Nomenclature of Nutritional Types of Microorganisms," which was composed by participants in the symposium.

In a brief review it is impossible to discuss all the papers presented. In general, those papers whose topics are closest to the reviewer's interest will be discussed, and consequently failure to mention further any one paper does not indicate that it was of lesser significance than those reviewed.

The basic aims of genetic studies on microorganisms have much in common with those of developmental studies on higher organisms, viz., to gain insight into the nature and mode of action of the gene, and to learn more about the nature of the organism being studied.

The papers of the symposium reveal that a great deal has been learned about the nature of viruses and bacteria as a result of genetic studies on them. Thus it has been shown (Anderson) that phages of types T4 and T6 require l-tryptophane in order to become adsorbed onto *Escherichia coli*; that a virus may undergo several independent mutations, i.e., it may have several gene loci (Hershey); and that the degree of completeness of the phenomenon of mutual exclusion in mixedly infected bacteria is a function of the relation between viruses used for infection (Delbrück and Bailey). The more closely related the viruses, the more complete is the breakdown of mutual exclusion. A mutant and its wild type show no mutual exclusion whatever. The most interesting phenomenon reported by these authors is the occurrence of induced changes at the r-locus (mutations at this locus leading to more rapid lysis of the host cell) as the result of mixed infections with pairs from the group T2, T4, T6 in which one member of the pair is wild-type, the other r-type in form (e.g., $T2r^+$ with T4r yields T2r and $T4r^+$). It is not clear from the data whether these changes are induced mutations, as the authors are inclined to believe, or transfers of character such as Lederberg and Tatum claim for bacteria, or some other phenomenon.

The possibility of the existence of a sexual process in bacteria was suggested by Dienes as the result of his observations of *Proteus* and by Lederberg and Tatum as the result of experiments with *E. coli* involving mixed cultures of biochemical mutants. In the last mentioned experiments mixed cultures of strains, each of which was deficient in the ability to produce two different essential metabolites (e.g., strain 1 being unable to produce biotin and methionine, strain 2 unable to produce proline and threonine) would give rise to strains able to produce all four metabolites (prototrophs). These prototrophs arise with a frequency much greater than would be expected on the basis of mutation. The mechanism of this phenomenon is not yet clear, and further data are needed.

Demerec and Laterjet reported new data on the induction by ultra-violet rays and x-rays of "zero-point" mutations (mutations that express themselves before the treated bacteria pass through the first division following treatment) and "end-point" mutations (mutations which appear during subsequent division) in *E. coli*. The data do not permit any conclusions to be made concerning the mechanism involved in the induction of these mutations. In one of the most interesting papers of the symposium, McCarty, Taylor, and Avery reported in some detail on the factors necessary for the induction of heritable transformations of pneumococcal types. The authors emphasized that their conclusions are tentative and are to be considered as a working hypothesis. Their data do indicate, however, that at least three components of serum in addition to desoxyribonucleic acid are involved in the transformation phenomenon. These other components are concerned with the alteration of the surface of the Rough cells so that the specific desoxyribonucleic acid is taken up or adsorbed which induces the formation of a specific Smooth type.

The main emphasis in the papers dealing with fungi, yeasts, and protozoa lay on the role of cytoplasmic factors in gene action. The Lindegrens and Spiegelman, from work with yeasts, have evolved hypotheses involving cytoplasmic units (cytogene—Lindegrens; plasmagene—Spiegelman) which possess the capacity for self-duplication regardless of the presence or absence of specific genes. It is unfortunate that there is disagreement between the Lindegrens, on the one hand,

and Spiegelman, on the other, with regard to the basic data concerning the spores derived from hybrids. The Lindegrens find, contrary to Spiegelman, that the presence or absence of the specific substrate does not influence the frequency with which all four spores of a heterozygote are fermenters, nor do they find that "masked" recessives (i.e., genotypic nonfermenters but phenotypic fermenters) necessarily lose their ability to ferment the substrate when cultured in its absence. It is likely that these disagreements will be resolved by further experimentation. It is also probable that as a consequence of further work the theories offered by these authors will be considerably modified.

Sonneborn reviewed the results of the work done by himself and his colleagues with the "killer" mutation in *Paramecium aurelia*. From data showing that the rate of production of kappa is independent of that of the gene, K, Sonneborn no longer believes that kappa is multiplied as part of the gene, but that the presence of K is necessary for the maintenance of kappa. His discussions of Dauermodification, "Aging," and the life cycle in protozoa in the light of the kappa—gene relationship is provocative.

The organizers of the symposium are to be congratulated not only for the obviously excellent planning that went into its formulation, but also for their flexibility of plan, evident from the inclusion of four papers added to the symposium because of their pertinence. It seems unfortunate that the papers are arranged in the volume in alphabetical order by authors, rather than in the original order of presentation, which is quite as logical for a reader of the volume. As it is, the reader interested in a particular organism must peruse the entire table of contents to identify the proper papers and then skip about through the volume to find them. It is to be hoped that in future volumes the papers will be published in the sequence in which they were presented. The table of contents can serve to locate any given paper.

ARTHUR G. STEINBERG

CYTOGENETICS OF THE GENUS NICOTIANA. *Karyosystematics, Genetics, Cytology, Cytogenetics and Phylesis of Tabaccos.*

By Dontcho Kostoff. State's Printing House, Sofia. Paper. XXVIII + 1073 pp. + 1 plate + 1 map + 2 tables; text ill. 1941-1943.

Throughout the history of botany, species of tobacco have served as objects for classical studies on basic problems such as fertilization, viruses, and photoperiodism, while in the narrower field of genetics synthetic allopolyploidy, self-incompatibility, and monosomics were thoroughly analyzed first in *Nicotiana*. Considering this great interest in the genus, Dontcho Kostoff's monograph is highly welcome. The author, now of Sofia, is particularly qualified for such an undertaking, as he has been one of the most active students of the genus for two decades. The present book is a result of his work on the cytogenetics of the genus and a wide array of related studies. It not only summarizes Kostoff's own researches, but it refers to practically the entire literature up to the beginning of World War II.

The first chapter is entitled: Karyosystematics. It is well illustrated, and practically every species is pictured. For his systematic studies the author has brought together a large collection of species, comparable in completeness to the one grown by T. H. Goodspeed in California. A comparison of the organization of the genus by the two authorities reveals a number of differences, of which the most conspicuous example is the placement of *N. sylvestris*. Kostoff assigns it to the same section with *N. tabacum* on a morphological and cytogenetic basis, while Goodspeed places it in the *Alatae*, using chromosome morphology as an additional criterion. A satisfactory solution appears difficult, as the species has distinctive features setting it quite apart.

Two chapters are devoted to interspecific hybridization before and after the turn of our century. The work of Kölreuter and his successors is reviewed. Considerable space is devoted to a richly illustrated description of interspecific hybrids, their morphology, and their reproductive behavior. Mention should be made of the disagreement between Kostoff and the California school regarding the amount of conjugation in species hybrids. Kostoff consistently describes a much higher degree of pairing than has been found by the Californians. One might be inclined to ascribe this wide discrepancy to differences in their conception of a bivalent. Unfortunately, the meiosis of hybrids is the only subject which is scantily illustrated by Kostoff. The few pictures he gives of it do not support such a supposition.

In the chapter on Genic Analysis, the mutants of three species and their modes of inheritance are listed and the Russian work on the inheritance of alkaloid synthesis, including graft experiments, is considered. The fifth chapter covers structural and numerical chromosome alterations caused by x-rays, aneuploidy, and autopolyploidy, and includes an extensive account of haploidy. A discussion of evolutionary relationships concludes the book.

It is unfortunate that only a small group of specialists will be able to profit properly from this work, as several defects reduce its value for a wider audience. On many a controversial issue the pros and cons are not duly documented. The organization is loose and it is thus difficult to use the volume for reference, especially as there is no index. Furthermore, the more outstanding highlights of *Nicotiana* research are swamped in the telling by redundant detail. Even so, the book is the most complete compendium of cytogenetical data on *Nicotiana* available to-day.

D. U. GERSTEL

AN INTRODUCTION TO THE GENETICS OF HABROBRACON JUGLANDIS ASHMEAD.

By Albert Martin, Jr. The Hobson Book Press, New York. $3.50. xiv + 205 pp.; ill. 1947.

Any animal which has produced motherless sons and fatherless daughters deserves to have a book written about it. The volume under discussion is a consolidation of investigations carried out on a small parasitic wasp over the past thirty years by P. W. Whiting and his associates, and published in various periodicals.

For those unacquainted with the insect there is a description of its form, its biology and methods for its culture. The bulk of the text reports the genetic and cytological studies. The list of mutant types is long, coming to well over one hundred, most of these being inherited visible changes in morphology or in color of eye or body. All are briefly described and those of especial interest are discussed at some length. There is a chapter on linkage, which is peculiar in that the majority of genes are in one linkage group despite the cytological evidence of ten pairs of relatively equal-sized chromosomes. The discussion of environmental effects upon the wasp is restricted mainly to temperature (pigment production, viability, etc.) and to x-radiation (mutations, chromosome fragmentation).

To the general geneticist, probably the most important chapters are those describing the production of normal and anomalous sex types and particularly the method of sex determination. The kernel of this unusual method of sex determination lies in the thesis that femaleness results from heterozygosity for a pair of sex genes, maleness from homozygosity. For example, an individual having the sex alleles $x^a x^b$ is a female, while one having the alleles $x^a x^a$ or $x^b x^b$ is a male (diploid, often non-viable, and usually sterile). The haploids have no choice; being either x^a or x^b alone they are, perforce, males and quite normal. Other sex alleles have been picked up in wild populations taken from various localities, so that, speaking for the species as a whole, a total of nine alleles have been cross-tested.

Of major interest to those intending to work with this species are the thirty pages of bibliography; this list of papers is complete for the subject. The text too often depends upon long quotations from the articles included in the bibliography, whereas a more concise summary would have served better. However, the book will be of interest to biologists who wish to diverge from the usual textbook genetics. It will obviously be greatly appreciated by those students and research workers who are, as the author states it, Habrobraconologists.

B. R. SPEICHER

NERVOUS DISEASES AND MUSCULAR DYSTROPHIES. *Part IV. On Pseudohypertrophic and Allied Types of Progressive Muscular Dystrophy. The Treasury of Human Inheritance, Volume IV.*

By Julia Bell. Cambridge, at the University Press; The Macmillan Company, New York. $6.00 (paper). Pp. 279–341 + 12 plates. 1943.

Volume IV, Part IV of *The Treasury of Human Inheritance* continues that fine tradition of throughness in the survey of the literature and of completeness of presentation which one has grown to expect of the series. In this issue, Julia Bell has compiled a bibliography of 159 papers and has presented in detail 273 pedigrees "On Pseudohypertrophic and Allied Types of Progressive Muscular Dystrophy." The textual material consists of an Introduction, which includes a historical review and a description of the material, and five chapters: The Genetic Classification of Cases; On the Age of Onset and Duration of the Disease; On Fertility in Stocks Carrying Muscular Dystrophy; On the Prognosis of the Disease and Cause of Death; and On the Inheritance of Muscular Dystrophy. The discussion under each of these headings is concise and adequately buttressed by summaries of the data in tabular or graphic form. The bibliography and the pedigrees cover the period from 1797 through 1942. Twelve hundred and twenty-eight cases were collected from the literature, and an additional 113 cases were obtained from hospital records covering the period from 1926 through 1940. The war interfered with plans to carry out a "genetic" examination of the parents and siblings of the latter cases.

The cases were classified under three genetic groups: the sex-linked, the recessive, and the dominant; as well as under three clinical groups: (A) the pseudohypertrophic, characterized by the enlargement of certain muscles, associated with wasting of others and with progressive weakness in all the affected muscles; (B) cases of atrophic muscular dystrophy with no history of muscle enlargement at any phase of the disease (in neither of the above groups are any of the facial muscles involved); (C) all cases in which facial muscles are affected. Some cases of each of the clinical types appear in each of the three genetic groups, but not with equal frequency. Thus Type A is very frequently sex-linked in heredity, whereas Type C is rarely so. Types B and C are frequently dominant, whereas A is rarely so. It seems likely that the same gene can cause any one of the three clinical types. This view is supported by data which indicate that more than one type may occur in a given pedigree. In the sex-linked group, cases tend to arise early in life and to run a rapid course; dominant cases may arise later in life, run a slowly progressive course, and a considerable number of patients survive to old age; cases in the recessive group are intermediate. The data indicate that the fertility of those patients who

marry is not reduced. The chapter on prognosis of the disease points out that no method of staying the progress of the disease is known. Death seems to result from lowered resistance to infection rather than from any specific cause.

Clinicians as well as geneticists will find this issue of *The Treasury of Human Inheritance* of enormous interest.

ARTHUR G. STEINBERG

FAMILY SKELETONS.

By David D. Whitney. University of Nebraska Press, Lincoln. $4.00. xii + 284 pp.; ill. 1946.

In the author's own words, this book "... is written not for the professional geneticist but for the layman and the medical student interested in human heredity." It is the author's hope that "the collection of photographs. . .may serve as a guide-book for amateurs in the study of undesirable traits, whether of major or of minor importance."

Scientific books written for the layman must be scrupulously accurate in order not to mislead. Furthermore, a book written to "stimulate [amateurs] to undertake studies" must present some insight into the techniques and pitfalls involved in these studies. This book fails miserably in both these requirements. It is grossly uncritical in what is accepted as evidence of a hereditary basis for the determination of a given character. For example, in one illustration, by no means unique, a family tree in which normal parents have four normal children and one abnormal child is offered as evidence that the trait "seems to act as a recessive" (Fig. 171). The book is inaccurate in presenting factual material as well as in genetic interpretation. Thus the author states that "a family, if it has cataract, is characterized by only one type" (p. 59); he refers to "Aryan Races" (p. 31); he says that in hemophilia the enzyme prothrombin is lacking (p. 164); he states that only 2 to 3 per cent of men are affected with red-green blindness (p. 167), etc., etc.

The author seems to be unclear as to the meaning of certain basic genetic terms. Thus on p. 2 we find him saying that "traits are called dominant, because when present, they are in evidence, and their opposites are called recessive, because they are not always evident when present—*unreal as this may seem*" [italics added]. The glossary at the end of the book contains such gems as "Germ Plasm: the part of the germ cell which transmits the hereditary characters" and "Evolution: progressive development from simple to complex organization." There are several others.

In conclusion, this book is definitely not to be recommended for the layman, nor anybody else.

ARTHUR G. STEINBERG

FOREST TREE BREEDING AND GENETICS. *Imperial Agricultural Bureaux, Joint Publication Number 8. By R. H. Richens. Imperial Bureau of Plant Breeding and Genetics, Cambridge; Imperial Forestry Bureau, Oxford; Imperial Agricultural Bureaux, Penglais, Aberystwyth, Great Britain.* 5s. (paper). viii + 79 pp. 1945.

Although systematic breeding work with forest trees was initiated more than two decades ago, relatively little work has been done in this large and important field, and practical benefits worth mentioning have yet to be obtained from such work. This unfortunate situation may be attributed, perhaps, chiefly to the fact that singular advantages, innate in the materials and conditions of silviculture and capable of accommodating an early realization of practical benefits, were, until recently, completely overlooked; while, from the outset, profound skepticism, induced by the awesome magnitude of certain supposed obstacles, militated powerfully against the establishment and support of forest-tree-breeding projects. Meanwhile, however, an extensive literature, much of which is difficult of access, has accumulated, particularly since 1930. A collation of this recent literature in four parts (1. Introduction; 2. General Principles; 3. Gymnosperm Tree Breeding; and 4. Angiosperm Tree Breeding) forms the body of this publication which contains also (1) a preface stating purpose and acknowledgments; (2) a dual index that facilitates reference to subjects treated in the text; (3) a foreword by H. G. Champion, an eminent British forester; (4) a glossary of almost 300 terms used in botany, cytology, forestry, genetics, and other fields; (5) a summary in four languages; and (6) a bibliography of more than 600 items.

The Introduction is actually not part of the compilation. It is essentially a justification of forest-tree-breeding work, apparently intended to stimulate an activating interest in such work, particularly in Great Britain, where the need for it is acute. The argument is neither concise nor well integrated. Instead of proceeding step by step from premise to conclusion, it follows a desultory course, meeting the objections usually marshalled against such work. This course compels the inclusion of subjects that are not adapted to the purpose, and it often leads to rationalization. Thus, considerable space is devoted to low thinning or unintensive phenotypic selection, pure line breeding, discovery of correlations, and other inappropriate subjects. The main justification is found for the use of heterotic hybrids and superior polyploids, which, it is said, promises immediate rewards. It is doubtful that this justification is technically adequate, however convincing it may be. The production of heterotic hybrids is likely to be achieved relatively rarely, since the usual result of crossing is an intermediate hybrid. Similarly, discovery of a superior

polyploid is likely to be a rare event, while the synthesis of such a polyploid, followed by use of its offspring, will generally be a slow process. A very strong case could be erected solely for the use of intermediate hybrids; but this point was omitted though the concept was available. In such a case, early rewards, flowing from the fortuitous discovery of superior polyploids or from an occasional production of such polyploids and heterotic hybrids, might be suggested, not to prove the point, but merely to strengthen the case.

This section is provocative for other reasons also. Some of the exposition lacks clarity, particularly that on the mode of inheritance, which, while not needed by the geneticist, is likely to be unintelligible to forester and layman alike, even with the aid of the glossary. Important distinctions are ignored: different kinds of thinning are not distinguished, and it is implied that "long term breeding" and "pure line breeding" are synonymous (p. 3). This section should prove helpful to legislators and others who may be confronted with the problem of deciding whether or not to advocate or initiate forest-tree-breeding projects. It should prove useful also to administrators, upon whom the responsibility for organizing such projects may fall, since it touches on that problem with precedents in view.

The section on General Principles, essentially a guide to theory and practice, presents under each of the 22 topics listed in the dual index appropriate concepts or conclusions. Considering the number and province of these topics, it is not at all surprising that this section too should provoke much criticism. Some of the topics—Natural Variation, and Quality, for example—are virtually battlefields onto which one should venture only if sheathed in shining armor. Richens' treatment of Natural Variation (about 2500 words), in which he constantly keeps the breeder in mind, is excellent. It contains, however, a needless exaggeration:

> A detailed knowledge of the taxonomy of tree species is therefore a first necessity for the tree breeder (p. 4).

This implies that a lack of knowledge is a valid objection to pursuance of improvement. The fact overlooked here is that, in some instances, an art has preceded, and even aided, a science which then, as it advanced, contributed immeasurably to the highest development of the art. It is not improbable that tree breeding will result in contributions to various fields of knowledge, including taxonomy. In fact, this is indicated in the last part of the discussion of "Natural Variation." The statement under Effects of Environment that the ultimate test of a tree must be made with its offspring (p. 7) overlooks the fact that the use of clones, which is sometimes possible, is preferable. Moreover, study of a progeny would not yield conclusive data regarding the heredity of the seed-parent unless pollination were controlled and knowledge of each parent's heredity were available. Under Genetical Analysis and also in the Introduction, the province of the gene is needlessly extended to include the extra-nuclear entities to which cytoplasmic inheritance is attributed. Summing up, however, this section is well done and should be very useful.

The two sections Gymnosperm Tree Breeding and Angiosperm Tree Breeding comprise an invaluable working tool which now supplies a long-standing need of the forest-tree-breeder. In these sections Richens has compiled by species most of the information then available on each of the 22 topics on which data had been obtained. This accomplishment compensates in overflowing measure for the defects of the other sections.

F. I. RIGHTER

HEREDITY: *An International Journal of Genetics. Volume I, Part I, July 1947.*

Edited by Cyril D. Darlington and Ronald A. Fisher in collaboration with G. W. Beadle, T. Caspersson, Th. Dobzhansky, B. Ephrussi, and Ø. Winge. Oliver & Boyd, Edinburgh. Annual subscription, 40s. or $8.50; single numbers, 14s. or $3.00. Published three times a year.

Heralded in the prospectus as a new departure in the effort to present the findings of workers in experimental breeding, cytology, statistical and biochemical genetics and evolutionary theory to the general scientific public, this new journal, it must be said, hardly appears in actuality to be different in character from such existing journals as *Genetics* and the *Journal of Genetics*. Perhaps future issues will establish a more distinctive pattern.

The contents of the first issue are as follows: Genetic Research in Britain, 1939–1945; A Bibliography of genetic research published in Italy and Germany, 1939–1945 (A. Buzzati-Traverso); A directional change in the genetic constitution of a natural population of *Drosophila pseudoobscura* (Th. Dobzhansky); Colour inheritance and sex determination in *Lebistes* (Ø. Winge and E. Ditlevsen); Competition and dominance of incompatibility alleles in diploid pollen (D. Lewis); The theory of plant breeding for yield (O. H. Frankel); An alteration in gene frequency in *Ricinus communis* L. due to climatic conditions (S. C. Harland); Methods of analysing the virulence of bacteria and viruses for genetical purposes (L. L. Cavalli and G. Magni); Linkage of rex with shaker-2 in the house-mouse (D. S. Falconer); Undulated: a new genetic factor in *Mus musculus* affecting the spine and tail (M. E. Wright).

Paper and printing are exceptionally fine. Halftones are reproduced on suitable glazed paper.

GENERAL AND SYSTEMATIC BOTANY

KEYS TO WOODY PLANTS. *Fifth Edition.*
By W. C. Muenscher. Comstock Publishing Company, Ithaca, New York. 50 cents. iv + 108 pp.; ill. 1946.

The latest edition of this convenient book of keys has been improved in a number of minor ways. To the keys to the genera have been added page citations to the species keys. These cross references ought to be of great assistance to the user. A few species have been added to the keys to species and some nomenclatorial changes made. The keys are followed by a systematic list of the species included in the keys. The next section, a reference list of publications on woody plants, has been brought up to date. The manual closes with a glossary, illustrations of terms used in describing leaves, inflorescences, and winter buds, and an index.

HANDBOOK OF THE TREES OF THE NORTHERN STATES AND CANADA *East of the Rocky Mountains.*
By Romeyn Beck Hough. The Macmillan Company, New York. $5.50. x + 470 pp.; text ill. 1947.

A modified version of Hough's 1907 *American Woods*, the *Handbook* is designed as a ready means of tree identification, even by the inexperienced layman, at the same time that it provides technical information of interest to the trained botanist or forester. Each species receives a double-page treatment including description, distribution map, and photographs of trunk, foliage, stem, and fruit. In some instances a 15-diameter photograph of a transverse section of the stem accompanies the text. An analytical key to the species described and a glossary complete the book. Printed on glossy paper, the photographs are excellent and the descriptions reliable.

C. P. SWANSON

THE STORY OF PLANT LIFE. *A Puffin Picture Book.*
By Isabel Alexander. Penguin Books, Harmondsworth, Middlesex, and New York. 2s. 32 pp.; ill. No date.

This is a short course in botany in 31 pages. Written for the elementary school student, the pamphlet is simply and effectively presented with a minimum of technical terminology. An introduction to the experimental method of learning should spur the imagination of the curious youngster.

AMERICAN WILD FLOWERS. *Hastings House Americana.*
[By Emma C. Embury; ill. by Edwin Whitefield.]
Hastings House, New York. $1.00. 40 pp.; ill. 1946.

In this tiny gem of a naturalist's book are sixteen exquisite plates by Edwin Whitefield, reproduced, together with the accompanying text, from *American Wild Flowers in Their Native Haunts*, a popular book on the native flora, written by Emma C. Embury, and published in 1845. The lovely colored representations of plants in leaf and flower are set against gray scenic backgrounds depicting actual American localities as they looked at the time. Illustrated are the bluet and wild geranium, wild rose, harebell, pipsissewa, wild strawberry, eyebright, azure starflower, dog's-tooth violet, blue-eyed grass, slender-leaved gerardia, wild columbine, wild honeysuckle, mountain laurel, four-leaved milkweed, bellwort, and cardinal flower.

BENTLEY GLASS

PLANT PHYSIOLOGY

TRACE ELEMENTS IN PLANTS AND ANIMALS. *American Edition.*
By Walter Stiles. Cambridge, at the University Press; The Macmillan Company, New York. $2.75. xii + 189 pp. + 7 plates. 1946.

Proof that plants are able to grow on a purely inorganic medium containing certain essential elements was obtained almost a century ago. The importance of this finding, which is a principal basis for present artificial fertilizer practices, cannot be overestimated. Indeed, it seems doubtful that the present size of world population, with current living standards, could even have been approached without it. In spite of this, increase in basic knowledge of plant nutrition has been slow. Information on the kinds and relative quantities of elements required for plant growth is not yet complete, and our ignorance of the function of each individual element in nutrition is appalling. At the turn of the century it became apparent that, in addition to the elements required in relatively large amounts, others were equally essential but were needed in only minute quantities. Mn, B, Zn, Cu, and Mo may now be said to be definitely established members of this essential group of so-called minor elements, micronutrients or trace elements. Considerable evidence points to the essential requirement of a number of other elements.

The improvements in vigor and yield of crop plants, and the extension of land suitable for cultivation, as well as the elimination of certain diseases of both plants and farm animals, which have already resulted from the practical use of trace elements in agriculture throughout the world in the last twenty years represent remarkable achievements. The importance and also

the role of trace elements in nutrition compares very closely with that of the vitamins. It is both surprising and disappointing, therefore, how little public attention and support has been given to the subject of mineral nutrition as compared with the tremendous interest, "educational propaganda," and financial aid bestowed on the subject of vitamins. Numerous books have been written on vitamins, but as far as I am aware the present book is the first comprehensive treatment of the trace elements written in English. The only closely comparable work, *Biochemie der Spurenelemente*, by Karl Scharrer, was published in Germany in 1941. The need for such a book is therefore self-evident.

Stiles has been a recognized leader in the field of the mineral nutrition of plants for several decades, and his experience covers all phases of the development of the work on trace elements. He is, therefore, eminently qualified to present this material and to evaluate the results.

The present book gives methods of analysis, their applicability, and their limitations. It presents data on the ranges of normal and abnormal concentrations of the trace elements in tissues and in soils, including data on elements which are toxic in low concentrations. The symptoms and distribution of deficiency diseases in plants are carefully and systematically treated. An excellent critical review is given of our present limited knowledge of the function of each of the various trace elements in nutrition. In general, the work on plants has been emphasized, although one chapter is devoted to deficiency and toxicity diseases and to the functions of trace elements in animals. Here also stress has been laid on the important relationships which exist between the mineral element contents of the soil and plants and the nutrition of animals of particular regions.

Examples cited throughout the book of relationships between concentrations of particular micro-elements in the soil or tissues and symptoms of deficiency or disease of organisms are often average values, which perhaps are even too striking, in the sense that they tend to make the reader overlook the well-known difficulties encountered in attempts to establish quantitative relations in individual cases between concentrations found in tissues or soil with optimal requirements or deficiency symptoms.

In the last chapter, Concluding Remarks, the author points to the importance of trace elements both in regard to normal growth and to pathologic conditions of plants and animals. He summarizes the evidence for their functional role as catalysts (coenzymes), their relations to the requirements of major elements and their relation to the conditions of the soil, its reaction, organic content, and microflora. He calls attention to the need for studies on the balance, first, between nutrients of different kinds, and second, between these, soil conditions and environmental factors; and he indicates the probable direction of and prospects for further knowledge in physiology and pathology to be gained from future work in this field. A very valuable and complete bibliography is appended.

Photographic material, included to illustrate symptoms of deficiencies, is not colored and therefore does not compare with the excellent illustrations found in *Hunger Signs of Crops*.

The subject matter has been carefully selected, critically evaluated, and clearly presented. The book is remarkably concise, and still it not only vividly reproduces essential facts but also reflects much of the spirit of the original literature. It should prove of the greatest value to students and investigators in biology and agriculture and may be read with profit by anyone interested in the general field of nutrition.

FOLKE SKOOG

COMMERCIAL FERTILIZERS: *Their Sources and Use. Blakiston Books on Agriculture. Fourth Edition. By Gilbeart H. Collings. The Blakiston Company, Philadelphia and Toronto.* $4.50. xiv + 522 pp.; ill. 1947.

The heavy increase (about 50 per cent) in fertilizer consumption in the United States during the recent war makes the appearance of this new edition very timely. This fourth edition of a popular and excellent text-book and reference, the third edition of which was published in 1941, brings the subject of commercial fertilizers up to date. The revised sections contain the contributions found in some 140 selected articles that were published during the war period. The textual matter has been expanded by 34 pages, and 29 figures and 29 tables of data were added. A new chapter is devoted to ammonium nitrate, a fertilizer that came into common use about 1943. The fire and explosion hazards incident to handling this product, although mentioned, probably are not emphasized sufficiently in the light of several recent disasters.

The first chapter is devoted to the history of fertilizer use. Ten chapters describe the manufacture and use of fertilizing materials containing the important nutrient elements, nitrogen, phosphorus, and potassium. Three chapters cover the use of fertilizers containing the less essential and non-essential mineral elements absorbed by plants. The remaining four chapters are devoted chiefly to mixed fertilizers, fertilizer practices, the determination of fertilizer needs, the effects of fertilizers upon crops, and the economic factors to be considered in fertilizer utilization.

The subject matter is very readable and within the scope of the title is complete. No attempt has been made to cover the broad subjects of soil fertility, soil management, or soil building in detail. A book of this length also does not permit the inclusion of individual fertilizer recommendations for each of the different crops, soil types, or climates.

JOHN H. MARTIN

PLANT RESPONSES TO MOLYBDENUM AS A FERTILIZER. *1. Molybdenum and Symbiotic Nitrogen Fixation; 2. Factors Affecting the Response of Plants to Molybdenum. Bulletin Number 198.*

(1) By A. J. Anderson and Margaret P. Thomas; (2) by A. J. Anderson and A. C. Oertel. Council for Scientific and Industrial Research, Melbourne, Australia. Free upon request (paper). 44 pp. + 7 plates. 1946.

ECONOMIC BOTANY

CROP PRODUCTION AND ENVIRONMENT.

By R. O. Whyte. Faber and Faber, London. 25s. 372 pp. + 32 plates. 1946.

In this amply illustrated monographic publication the author, an indefatigable collector and interpreter of research data and records on practical experience, has summarized an impressive amount of information on the subject. The reader of this book is taken in hand to observe and hear a discussion of a number of very active fields of investigation on developmental physiology. Unless he be a specialist in the field, he will feel not unlike one who is viewing the building of several edifices, in various stages of construction, whose final forms and times of completion are difficult to visualize or predict.

Specifically, the book deals with the growth and development of plants, chiefly economic, as they are affected by temperature, light, and hormone secretion. The first three chapters cover in a general way plant development, with special reference to the separate phases, as postulated by Klebs and later elaborated by Lysenko and others. Vernalization, photoperiodism, and the effects of sexual reproduction on growth are given considerable emphasis. In the following two chapters the author discusses in detail the effects of temperature, vernalization and devernalization, thermoperiodism, and related phenomena. This is followed by an analysis of the formative effects of the photoperiod on plant growth and development, with main reference to reproduction. Information on the interval physiological effects of the above environmental factors and the function of specific, largely postulated, hormones is somewhat brief, which of course is not the author's fault.

The rest of the book, fully one-third, is devoted to the general application of the experimental results to agricultural practices of crop production. Some salient features of the geographical distribution of crop plants are presented. The selection and breeding of specific agronomic and horticultural plants for adaptability to temperature and light regimes is presented and amply illustrated. Quite a complete bibliography of several hundred references is appended, listing scientific and applied publications to and including the year 1945. There is inserted a brief glossary of terms, based largely on Chamber's *Technical Dictionary*, and not as desirable and complete as one would wish for the uninitiated reader.

This book should be of considerable value to all teachers and investigators of plant life. The information presented in it deals with certain very active fields of investigation, not to be found as yet or only briefly mentioned in our textbooks of botany or manuals of plant culture.

A. E. MURNEEK

THE PRODUCTION OF TOBACCO. *Blakiston Books on Agriculture.*

By Wightman W. Garner. The Blakiston Company, Philadelphia and Toronto. $4.50. xiv + 516 pp.; ill. 1946.

The aborigines of the Americas had developed the manufacture of crude forms of cigars and cigarettes, as well as the use of tobacco in pipes, as snuff, and for chewing, at the time when Columbus discovered the product in 1492. The history of tobacco coincides with the history of man in America.

Garner, an international authority on the subject, has written the only book devoted exclusively to tobacco to be published in the United States within the past four decades. Unquestionably, it is the best work on tobacco ever printed. Part One (two chapters) covers the botany and growth characteristics of the tobacco plant, the world production and international trade in tobacco, the classification and uses of American tobacco, the history of the tobacco industry, and the present distribution of production in the United States. Part Two (12 chapters) covers the culture, curing, grading, and marketing of tobacco (including production in foreign countries), tobacco varieties, economics of tobacco production, and the diseases and insect pests of tobacco, together with methods of control. Part Three (9 chapters) is devoted to the morphology, physiology, chemistry, and genetics of the tobacco plant; its soil and climatic requirements; the scientific aspects of tobacco curing, fermentation, and aging; tobacco quality; and tobacco manufacturers. The extensive bibliography occupies nearly 16 pages.

The author, who for 38 years directed tobacco research in the United States Department of Agriculture, has correlated scientific principles with practical operations to a remarkable degree. Users of tobacco, as well as those concerned with tobacco production, marketing, and manufactures will find this book extremely interesting.

JOHN H. MARTIN

PLANT MAGIC.

By James P. Haworth. Binfords & Mort, Portland, Oregon. $3.00. xviii + 148 pp. + 24 plates. 1946.

Why plant "magic," unless it be for reason of salesmanship? (In the Introduction the author says: "Many years ago I worked under a forceful sales manager who had very original methods of impressing a point.") There is nothing magic in nature, only reality, understood or yet to be disclosed.

This little booklet opens with a Prologue crowded with sentimental verbosity and very little short of a prayer for Him from whom all blessings come. Since the readers are assumed to be mainly, if not entirely, "nature lovers" and not plant scientists, the author has deemed it desirable to cover in Part One (four chapters) very briefly and hurriedly plant origins and evolution, the growth of plants, the plant's food supply, and sexual reproduction. This is really covering "some" territory. One is left with the feeling that if so little is said on so much, why say it at all. Will the layman comprehend the more obscure discussions further on if taken so briefly in hand?

The main body of the booklet, Part Two (18 chapters), deals with naturally and artifically induced mutations. Beginning with a cursory discussion of mutations in nature—kind, frequency of occurrence, and value—the author next launches into a description of methods for inducing mutations artificially. While briefly listing the many techniques used by scientists, the one suggested for amateurs is perforce limited to the use of colchicine and similar substances. Various procedures are given for application of this alkaloid, its visible and invisible effects are listed, and the difficulties involved in obtaining results are mentioned. Unnecessary for the layman, perhaps, since the procedures most likely would not be used by him, are several chapters devoted to the technique and effects of irradiation and of treatment with heat, cold, centrifugal force, etc., to obtain mutations. Finally, saying to the reader in the last chapter, "Now you are on your own," the author gives necessarily a detailed procedure, to those who are interested in "creating something original," for the treatment of seeds with colchicine and the use of this chemical on buds, leaves, shoots, etc.

The appended photographs showing the effects of colchicine on growth and form, mostly abnormal in appearance, certainly will create no enthusiasm in the amateur experimenter. Where are, visibly, some of the promised new "magic creations"?

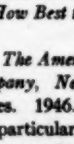
A. E. MURNEEK

THE ENCYCLOPEDIA OF TREES, SHRUBS, VINES AND LAWNS FOR THE HOME GARDEN.

By Albert E. Wilkinson; illustrated by Tobea Hofmann. The New Home Library, The Blakiston Company, Philadelphia. $1.00. x + 486 pp.; text ill. 1946.

Written for the New Home Library series, this inexpensive volume brings within the reach of everyone the wealth of information needed to provide the American home owner and gardener, possessing as he does a variety of soil and climatic conditions, with the background necessary for successful planting and maintenance of garden and lawn. No book can prescribe the proper plant for a particular place and the care it should receive thereafter—the circumstances are too varied, and plants, being what they are, respond variously. Sound instruction and information, carefully sifted and simply expressed, are basic, however, for those who would make the most of their landscaping possibilities without the expensive services of the expert. In a large measure, this objective is accomplished in this volume. Part I, covering 258 pages, alphabetically lists, describes, and gives the cultural characteristics and ornamental advantages and disadvantages of the individual trees, shrubs, and vines which the gardener would ordinarily use. Part 2 deals with the planting and maintenance of the same materials, including lawns, together with suggestions as to their proper use in the landscape picture. This is a worthwhile and usable book in any home gardener's library.

C. P. SWANSON



ALL ABOUT HOUSE PLANTS: *Their Selection, Culture and Propagation, and How Best to Use Them for Decorative Effect.*

By Montague Free. The American Garden Guild and Doubleday & Company, New York. $3.50. xvi + 329 pp. + 49 plates. 1946.

Success in gardening, particularly the indoor variety, has been attributed to possession by the gardener of a "green thumb," that indefinable something which enables some gardeners to grow plants in profusion and beauty with a minimum of care. This volume is an attempt to dispel some of the mysteries of plant behavior indoors, and to provide a sound basis for deciding what to grow and how to grow it. The attempt appears to be a successful one. Written in an easy, familiar style, and not without humor, the book deals first with the types of indoor gardens and their culture, and then with the kinds of plants which may be so used. In describing more than 1,000 plants, attention is given to the suitableness and the vagaries of each species. Particularly useful are the lists of species which can be grown in the special conditions one frequently encounters indoors. It is altogether an enjoyable and worthwhile volume.

C. P. SWANSON

FARMS AND FARMERS: *The Story of American Agriculture. The American Cavalcade Series.*

By William H. Clark. L. C. Page & Company, Boston. $3.75. xx + 346 pp. + 32 plates. 1945. This work, and two others by the same author (*Ships and Sailors*, and *Railroads and Rivers*) comprise "The American Cavalcade Series" of American history. *Farms and Farmers* is a history of agriculture in America, from the early explorations down to the present time. The unrest in Europe in the seventeenth century, the forests of America, and Indian agriculture are described in Part I. Part II covers the Colonial Period, with emphasis on the part played by tobacco and rice in colonial development. Part III is devoted to the period called "The Great Expansion, 1784–1861." The period from 1861 to 1929 is covered in Part IV. Part V contains descriptions of the "New Deal" Agricultural programs, recent research in agricultural sciences, and the American farmer of the future. The more important phases of American agricultural history are all covered at least briefly. Obviously, space did not permit the inclusion of histories of many important crops or of the agricultural development in each State or district.

With a few exceptions, the historical facts are presented with remarkable accuracy. Among the errors observed is a statement that the Carolina White variety of rice, which long since passed out of cultivation, "is now standard the world over and is grown everywhere." The ox is described as a "museum piece—it is one with the spinning wheel and the passenger pigeon," despite the fact that oxen are still used in rather appreciable numbers, especially in the New England woods. The author uses the term "germ plasma" instead of accepting the terminology found in the literature of biological scientists, viz., "germ plasm." Three of the twelve names in a list of improved crop varieties are misspelled. Twice in the text it is stated that Congress provided for the establishment of experiment stations in 1877, although the correct date of the passage of the Hatch Act, 1887, is given in the Appendix. A highly distorted picture of dry farming is presented. The author mistakenly assumes that a water table within reach of the roots of annual crop plants is present in dryland soils. The art of irrigation in America is credited to Spanish settlers rather than correctly to Indians of many centuries ago. The important bulb industry of Holland, Michigan, is overlooked in crediting the entire bulb industry to the Pacific Northwest. The author falls into the common error of assuming that the soils of the Virginia tidewater region were originally rich, and were depleted by cropping to tobacco, whereas the Indians were aware that only two or three crops could be grown on virgin land in those parts before the soil needed a "rest." The author assumes mistakenly that the Great Plains shelter belts were planted in the dry section where the severe dust storms of the 'thirties arose, whereas these plantings are 100 to 200 miles to the eastward, where more favorable moisture conditions permit trees to grow to an appreciable size. Cigars, cigarettes, and snuff, inventions of the Indian, are incorrectly credited to the white man.

Farms and Farmers is highly recommended as an interesting and informative sketch of the history of American agriculture. As a guide to agricultural policies, it lacks the touch of an agricultural expert.

JOHN H. MARTIN

THE USE OF MINERAL DUSTS FOR THE CONTROL OF WHEAT PESTS. *Bulletin Number 199.*

By Frank Wilson. Council for Scientific and Industrial Research of Commonwealth of Australia, Melbourne. Free upon request (paper). 31 pp. + 1 plate. 1946.

GENERAL AND SYSTEMATIC ZOOLOGY

FORAMINIFERA. *The Zoology of Iceland, Volume II, Part 2.*

By Aksel Nørvang. Ejnar Munksgaard, Copenhagen and Reykjavik. Kr. 7.50 (paper). 79 pp.; text ill. 1945.

87 species are now known off the coasts of Iceland down to a depth of 400 meters, following a distribution that is divisible into climatic zones, as for other Icelandic animals. Some species are distributed mainly in arctic waters; others are usually found in the warmer waters; and the majority occur in both.

L. H. HYMAN

TARDIGRADA. *The Zoology of Iceland, Volume III, Part 24.*

By S. L. Tuxen. Ejnar Munksgaard, Copenhagen and Reykjavik. Kr. 1.00 (paper). 11 pp.; text ill. 1941.

There is probably a large number of species of tardigrades in Iceland, but so far only 18 species have been recorded, mostly of the genera *Macrobiotus* and *Hypsibius*. None of the 18 species is peculiar to the region; 11 are cosmopolitan, and the others have been found in a number of localities, although three seem to prefer cold regions.

L. H. HYMAN

THE TREMATODA OF BRITISH FISHES.

By Ben Dawes. Printed for the Ray Society, London; sold by Bernard Quaritch, London. 45s. viii + 364 pp.; ill. 1947.

Dawes has quickly followed his previous volume, *The Trematoda*, with the present one, which will undoubtedly prove very useful to all students of fish parasites. The volume opens with a brief account of the Platyhelminthes and the Trematoda. Unfortunately, the author lists the Temnocephalida as a class of flatworms coordinate with Turbellaria, Trematoda, and Cestoda. This point of view was abandoned long ago, and it is now known that the Temnocephalida are rhabdocoels related to the dalyellioids. In regard to the Monogenea, the classification of Price, probably the best available, is followed. The aspidogastrids are properly recognized as a distinct order of trematodes, but none has so far been found in British fishes. In the Digenea the usual suborders, Gasterostomata and Prosostomata, are recognized, although it becomes increasingly evident that this arrangement cannot stand. The keys and diagnoses of suborders, families, and genera will prove very helpful.

L. H. HYMAN

MYRIOPODA. *The Zoology of Iceland, Volume III, Part 36.*

By S. L. Tuxen. Ejnar Munksgaard, Copenhagen and Reykjavik. Kr. 0.75 (paper). 9 pp.; text ill. 1941.

Only one millipede and four centipedes are known from Iceland, and it is improbable that more occur. All the Icelandic species are also known from Scandinavia and have probably been introduced into Iceland in relatively recent times. They live mainly in the warmer south and west parts of the island.

L. H. HYMAN

STUDIES OF SOUTH AMERICAN PSAMMOCHARIDAE. *Part I. Bulletin of the Museum of Comparative Zoölogy at Harvard College, Volume 96, Number 4.*

By Nathan Banks. Museum of Comparative Zoölogy at Harvard College, Cambridge. $4.50 (paper). Pp. 309–525 + 3 plates. 1946.

STUDIES OF SOUTH AMERICAN PSAMMOCHARIDAE. *Part II. Bulletin of the Museum of Comparative Zoölogy at Harvard College, Volume 99, Number 2.*

By Nathan Banks. Museum of Comparative Zoölogy at Harvard College, Cambridge. $1.00 (paper). Pp. 371–486 + 1 plate. 1947.

In this valuable and much needed work, Banks has brought together and classified known and new genera and species of South American spider-hunting wasps, but regrettably omits those of the Chilean fauna. Taxonomic keys, so desirable in comprehensive studies of this sort, are provided to genera, subgenera, and species. These are constructed principally for ease in the determination of pinned material, and not to portray affinities between genera or species. Accounts of newly described genera and species are extensive, and there are discussions of the limits and special problems of the subfamilies. Excepting for such characterization as they are given by the keys, most of the earlier described genera and species receive little more than listing and a record of their distribution from material studied. Since no bibliographic citations are provided, use of the monograph in reviewing the South American fauna will be awkward, until Banks' promise of a bibliographic catalog to all of the South American species is realized.

On the whole the major classification adopted is very conservative, even abandoning the tribal designations within the Psammocharinae (Pompilinae) that have been recently set up by Bradley (1944). No less than ten new genera, one new generic name, three new subgenera (all within *Pepsis*), one hundred and eighty new species, and a number of new varieties are described. The Pepsinae, Pseudageninae, and Cryptochilinae are treated in Part I. Part II deals with the Psammocharinae, Notocyphinae, and Ceratopalinae, concluding with an index to both parts.

KENNETH W. COOPER

MARINE GASTROPODA PROSOBRANCHIATA. *The Zoology of Iceland, Volume IV, Part 60.*

By G. Thorson. Ejnar Munksgaard, Copenhagen and Reykjavik. Kr. 14.25 (paper). 150 pp.; text ill. 1941.

109 living species have been found in Icelandic waters. Of these, 55 are arctic, 23 boreal and lusitanian, and 15 cosmopolitan. The arctic species inhabit chiefly the colder north and east coasts of Iceland, the lusitanian-boreal forms the warmer south and west shores. The majority of the species (83%) are also found on the Norwegian coast north of Lofoten; there is less similarity (61.5% in common) with the prosobranch fauna of the northeastern coast of North America. A further analysis of the distribution shows that the arctic element of the prosobranch fauna (40% of the Icelandic species) is distributed throughout the North Atlantic, whereas the southern element (18.3% of the Icelandic species) is found exclusively on European shores. Iceland is relatively rich in prosobranchs compared to such other geographically similar regions as Spitzbergen, Greenland, the Faroes, and northern Norway. The majority of Icelandic prosobranchs occur in shallow waters. Reproduction without free-swimming larval stages is characteristic of the arctic prosobranch fauna.

L. H. HYMAN

A Monograph of the West Atlantic Mollusks of the Family Aclididae. *Smithsonian Miscellaneous Collections, Volume 106, Number 20. Publication 3868.*

By Paul Bartsch. Smithsonian Institution, Washington, D. C. 30 cents (paper). ii + 29 pp. + 6 plates. 1947.

This monograph sets up four new genera (*Bermudaclis, Costaclis, Schwengelia, Henrya*) and describes 9 new species (1 of *Bermudaclis*, 1 of *Graphis*, 1 of *Aclis*, 3 of *Henrya*, and 3 of *Hemiaclis*). The plates show the small elongate-ovate to turreted shells of these gastropods greatly enlarged.

British Shells. *The King Penguin Books.*

By F. Martin Duncan. Penguin Books, London and New York. $1.00. 32 pp. + 16 plates. 1943.

This booklet comprises a selection of plates from Forbes' and Hanley's History of British Mollusca, with a brief descriptive text. The plates are well reproduced, and the text contains an unexpected amount of detail for so small a book.

Joel W. Hedgpeth

Cephalopoda. *The Zoology of Iceland, Volume IV, Part 64.*

By Anton Fr. Bruun. Ejnar Munksgaard, Copenhagen and Reykjavik. Kr. 1.50 (paper). 15 pp.; text ill. 1945.

Of the 14 recorded species, three are true coastal species, three more are deeper water forms (below 200 meters), and the others are regular or occasional guests.

L. H. Hyman

The Echinoderm Fauna of Australia: *Its Composition and Its Origin. Carnegie Institution of Washington Publication 566.*

By Hubert Lyman Clark. Carnegie Institution of Washington, Washington, D. C. $4.50 (cloth); $4.00 (paper). iv + 567 pp. 1946.

The greater part of this volume consists of an annotated list of the echinoderms of Australia, including the extinct ones, together with keys to the orders, families, and genera. As such, it will be of great value to students of echinoderms and of the marine fauna of Australia. About thirty pages are devoted to the question of the relationships of the Australian echinoderm fauna, and this discussion will be of general interest to workers in animal geography. The author follows previous students of the marine fauna of Australia in recognizing four provinces: the north or Dampierian coast, with 290 species, about half endemic; the Great Barrier reef area of Solanderian province, with 208 species, 40 per cent endemic; the south coast or Peronian province, with 107 species, 82 per cent endemic; and the western coast or Flindersian province, with 166 species, 89 per cent endemic. It is evident that the endemicity increases strikingly towards the southwestern corner of the continent where nearly all the echinoderm species are endemic, but the majority of the 787 species recorded from Australia occur on the north and east coasts, especially in the Torres Straits region. It is evident, therefore, that the echinoderm fauna of Australia has come primarily from the East Indian region. No evidence of common origin or close relationship was found between the Australian echinoderms and those of Mauritius, Madagascar, or southern and eastern Africa, whereas there is some relationship with the echinoderm fauna of the Arabian and Ceylonese areas through East Indian contributions. In regard to New Zealand, the endemicity of 80 per cent of its echinoderm species indicates long isolation; but there are some species common to New Zealand, Australia, and the East Indies, due to a common source in the fauna of the latter. No support is found in the echinoderm distribution for the theory of the existence of former connections between southern land masses.

L. H. Hyman

Fishes of Britain's Rivers and Lakes. *The King Penguin Books.*

By J. R. Norman. Penguin Books, London and New York. $1.00. 32 pp. + 16 plates. 1943.

This is one of the King Penguin Books, designed as an ornament for a library table, but nevertheless written by an authority. The late author's text is very slight, being little more than an outline of the biology, distribution, and origin of British freshwater fish. The plates are reproduced from Edward Donovan's *Natural History of British Fishes* (1802–1808), and there is a brief biographical note on Donovan as well as a short list of references.

Joel W. Hedgpeth

Tropical Fish. *Revised.*

By Lucille Quarry Mann; illustrations by Garnet W. Jex. Sentinel Books, New York. 60 cents (paper). x + 114 pp.; ill. 1947.

A revised and augmented edition of a concise and handy aquarium guide which first appeared in 1934. The additions include the latest gadgets for the home aquarium and the recent importations which have come into favor since the earlier edition. This is undoubtedly the

best buy among aquarium guides, especially for the beginner.

JOEL W. HEDGPETH

NORTHERN FISHES *With Special Reference to the Upper Mississippi Valley. Revised Edition.*

By Samuel Eddy and Thaddeus Surber. The University of Minnesota Press, Minneapolis. $4.00. xii + 276 pp. + 4 plates; text ill. 1947.

This revision (cf. Q.R.B. 19: 245. 1944, for review of first edition) has been undertaken to correct a number of errors, especially those regarding distributions that resulted from erroneous identifications in the early collection by Evermann and Latimer from the Lake of the Woods, and to incorporate new records. Several new illustrations have been added. The early chapters on Fisherman's Luck, Fishing Technique, Lake Dynamics, Fish Populations, Management of Waters for Fish Production, Improvement of Lakes and Streams, Laws and Propagation, and Parasites of Fishes have been enlarged and rearranged.

XENOPUS LAEVIS: A BIBLIOGRAPHY.

Compiled by H. Zwarenstein, N. Sapeika, and H. A. Shapiro. Published for the University of Cape Town by The African Bookman, Cape Town. 10s. viii + 51 pp. 1946.

This valuable bibliography of the South African clawed frog, *Xenopus laevis*, now so widely used for the diagnosis of pregnancy, lists 318 papers, suitably grouped under 19 subject headings, of which pregnancy diagnosis is only one. All anatomical and physiological departments, as well as Reproduction, Development, Pharmacology, Bacteriology, and Parasitology, are represented. Clearly *Xenopus* is becoming one of our more important laboratory animals. There are adequate author and subject indexes.

REVISION OF THE AFRICAN LIZARDS OF THE FAMILY GEKKONIDAE. *Bulletin of the Museum of Comparative Zoölogy at Harvard College, Volume 98, Number 1.*

By Arthur Loveridge. Museum of Comparative Zoölogy at Harvard College, Cambridge. $5.00 (paper). Pp. 1–470 + 7 plates. 1947.

Loveridge is at his best in techincal revisionary work, and this paper is both an excellent and a recent example. The African geckos are herein assigned to 204 forms among 28 genera. This thorough and meticulously executed work follows the widely adopted pattern: introduction, key to genera, specific accounts, and bibliography. A key to the contained species is incorporated in each generic account. For each species the available information is assembled under a variety of headings as: synonymy, native names, description, color, size, anatomy, breeding, longevity, sexual dimorphism, diet, parasites, enemies, temperament, defense, migration, habits, habitat, localities, range, and folklore. There are a number of tables which summarize, for a genus, the meristic data for various scale series and ratios for each species. Unfortunately, the number of specimens upon which the counts are based is not indicated.

Extreme care has been exercised throughout. For example, Loveridge set for himself a tedious task in order to insure a uniform rendering of locality names that had been transcribed from native pronunciations into English, French, or German. He took a duplicate copy of his manuscript, cut it up, sorted all locality names by country, and checked for non-agreements. He similarly handled the approximately 3000 bibliographic citations. There is every evidence that the zoological data were also assembled and presented in the same critical fashion. The somewhat longer descriptions of the habits and folklore of the better known species are pleasant, well-written oases in a highly technical account. There follows a bibliography of some 650 titles, believed to be a reasonably complete coverage of the literature between 1880 and 1940. Papers appearing earlier and later are also listed. An index to the names used and a series of 39 figures distributed among seven plates complete the book.

This monograph is the latest in a recent series of family revisions of African lizards: Amphisbaenidae, 1941; Gerrhosauridae, 1942; and Cordylidae (Zonuridae), 1944. These papers, along with other contributions by Loveridge, constitute an important segment of herpetological literature. They will doubtless remain authoritative and definitive accounts for many years.

ARNOLD B. GROBMAN

A BIBLIOGRAPHY OF BIRDS *with Special Reference to Anatomy, Behavior, Biochemistry, Embryology, Pathology, Physiology, Genetics, Ecology, Aviculture, Economic Ornithology, Poultry Culture, Evolution, and Related Subjects. Part 3: Subject Index. Zoological Series, Field Museum of Natural History, Volume 25, Part 3. Publication 581.*

By Reuben Myron Strong. Field Museum of Natural History, Chicago. $4.50 (paper). 528 pp. 1946.

The first nine pages of Part 3 (Subject Index) of Strong's *Bibliography* consist of a list of bibliographies devoted to birds and a list of periodicals containing abstracts and reviews of publications referring to birds. The remainder consists of topics, alphabetically arranged from the proverbial A (accidents) to Z (zoolo-

gies). Each major topic is subdivided into minor headings and those in turn, if the material warrants it, into further subdivisions. Thus under Behavior, the subtopic Sexual Behavior is divided into Courtship, Display Performances (including inflation), Marital Relations (fidelity of mates, length of period birds remain mated, matings between different species), and Nuptial Flight. These subtopics are set off in special type, but items within any one subtopic are arranged successively as books (classified according to language), general publications found mostly in periodicals, and general publications classified according to species or higher categories. This plan varies for smaller or greater subdivisions, depending upon the amount of material covered by the topic heading, but in every case information is provided on the context of the article. Reference is given only to author and date of publication, so that for a complete reference one must have recourse to Parts 1 and 2 of the *Bibliography of Birds*, containing the Author Index.

The year 1926 ended the author's comprehensive search of the literature, largely because Biological Abstracts was started at that time, although more recent references were added as they came to the writer's attention. Strong personally checked most of the citations, visiting many foreign libraries and institutions to verify their accuracy. Although taxonomic works have been excluded, there is still such a wealth of material (over 2000 periodicals alone were consulted) that a perfect compartmentalization is impossible. The only criticism that one could possibly have the temerity to raise is that the index is so comprehensive that certain topics are difficult to locate. In the Introduction, however, Strong mentions a forthcoming Finding Index. Zoologists will be forever indebted to the compiler for his painstaking labors and his perseverance in producing such an invaluable reference book.

HENRI C. SEIBERT

AUDUBON BIRD GUIDE: *Eastern Land Birds. Sponsored by National Audubon Society.*

By Richard H. Pough; illustrated by Don Eckelberry. Doubleday & Company, Garden City, New York. $3.00. xl + 312 pp. + 48 plates; text ill. 1946.

The large army of bird lovers will be delighted with this authoritative, complete and serviceable guide to the 275 species of land birds of eastern North America. For each species, listed systematically under its common and its scientific name, there are noted briefly the main points of identification, the voice, nesting and feeding habits, range, significant sex- and age-differences, etc. Of greatest help are the colored illustrations, more than 400 in number, by Don Eckelberry. They are faithfully executed, well reproduced, and give the easiest means for a quick, tentative identification of birds. By its pocket size, this volume is well adapted for field study and any of its factual information is readily located by means of a full table of contents and a detailed index. This guide includes a noteworthy Foreword containing many brief, excellent, popular essays on bird life in general, on the behavior, migration, distribution, special requirements, economic relations, etc. of birds, and with hints to the beginner on attracting and on observing birds. The chapter on conservation shows clearly that man is by far the worst enemy of birds, directly or indirectly, wantonly or unknowingly.

A. H. SCHULTZ

A FIELD GUIDE TO THE BIRDS, *Giving Field Marks of all Species Found East of the Rockies. Second Revised Edition. Sponsored by National Audubon Society.*

By Roger Tory Peterson. Houghton Mifflin Company, Boston. $3.50. xxvi + 290 pp. + 60 plates; text ill. 1947.

This, although called the Second Revised Edition of Roger Tory Peterson's well known standard *Field Guide to the Birds*, (cf. Q.R.B. 15: 483. 1940) might better be termed the third edition, for the changes made have been very extensive. The illustrations are new throughout, and there are now a great many more plates in color (36 in all, depicting 500 birds). Black and white, in the characteristic silhouette patterns Peterson has introduced, are retained wherever that would be a greater aid to identification than color. Cross references from plates to text, in addition to those from text to plates, have been inserted. This will be of enormous assistance in quickly looking up specific birds. Plates of the bills of terns, ducks overhead, and the confusing fall warblers are new, very helpful illustrations. For each species included in the text a section has been added on Similar Species, a feature that every user will applaud. Accidental species (recorded less than 20 times in Eastern North America) and Subspecies have been placed in separate appendixes at the back, so that the work of future revision of the handbook will be largely limited to that portion. About a dozen species, with which the author felt too unfamiliar, have been written up by such men as Griscom, Murphy, Broun, Sprunt, Sutton, and Van Tyne. These little signed contributions add a note of modesty on the author's part that is a fitting assurance that no labor has been spared to make this the best available guide to eastern birds.

BENTLEY GLASS

HOW TO KNOW THE LAND BIRDS: *Pictured-Keys for determining all of the Land Birds of the entire United States and Southern Canada, with maps showing their*

geographic distribution, and other helpful features. The Pictured-Key Nature Series.

By H. E. Jaques. Wm. C. Brown Company, Dubuque, Iowa. $2.50 (cloth); $1.50 (paper). iv + 196 pp.; ill. 1947.

The present volume is another that may be added to the recent outburst of field guides to North American birds. This time the entire United States is included within its geographical scope, but all aquatic birds have been omitted; they are to be presented in a forthcoming accompanying volume.

The entire book is made up as one huge key, a system followed in other members of the Pictured-Key Nature Book series. Following cursory chapters on bird life in general, on how to study birds, and on how to use the keys, there is a key to the terrestial orders of North American land birds. Each character in the dichotomy is illustrated by small pen-and-ink sketches. After the correct order has been selected, the student is referred by page number to the proper place to continue tracing down to specific determination. In this latter section black-and-white drawings show the essential morphological characters of the birds, and labels point out the more distinguishing colors. This description is supplemented by textual material giving size and general coloration. A small map shows the range of the species in question.

It is only fair to state that the following comments are offered before the book has been given an actual trial in the field, but the reviewer has found that beginning students in ornithology often have difficulty identifying birds with a key even with the specimen in hand, and that it is only after some experience that specimens can be correctly identified by key. It will take considerable observational power as well as good fortune to tell whether a bird that is partially hidden in dense foliage has two toes in front and two behind. By the time such a feature has been determined there is little doubt that the bird could be better known from its shape and color alone. A workable key to birds in the wild requires observational facilities so ideal that they are seldom encountered. This is not meant to imply that this guide is valueless. When the key is limited to color descriptions, as within a family, its efficaciousness is enhanced and should be of some use.

In a book of this type the identification of geographic races should be subdued or eliminated, but in this guide the races have been listed under the species and their general distributions plotted on the map. The latter is small enough without being encumbered with the hardly discernable ranges of forms hardly distinguishable (in the field), especially since, in most cases, the ranges delineate only the breeding areas. An attempt has been made to differentiate these forms as somewhat darker, smaller, etc., than the type, but the unreasonableness of this effort must have been evident even to the writer, since in several instances (e.g., Northern yellow-throat) additional subspecies have no descriptions whatsoever after them. It would have been better to save this space for a more complete description of the species themselves.

Dimorphic species have the females described with the males, but in some cases (e.g., indigo bunting), in order to arrive at the proper identification from the key, one must use the male coloration alone; in other cases (e.g., scarlet tanager) there is a separate key to the females and immature individuals.

HENRI C. SEIBERT

LIFE HISTORIES OF NORTH AMERICAN DIVING BIRDS: *Order Pygopodes.*

By Arthur Cleveland Bent. Dodd, Mead & Company, New York. $5.00. xiv + 237 pp. + 32 plates. 1946.

In 1910 Arthur Cleveland Bent began gathering material for publication on the life histories of North American birds. The first volume in this series appeared in 1919 under the above title. At present, fifteen volumes have appeared, several others are in the hands of the printer, and their author, now in his eighty-first year, is nearing the completion of his monumental task. Bent's *Life Histories* have long since become a standard reference for all students of North American birds, and it is not surprising that the early numbers, which were issued in small, paper-covered editions, are now rare and expensive. Dodd, Mead and Company have secured permission of the government and author to republish the first and rarest volume in this series. They state that this is an exact reprint and do not mention that the colored plates of eggs and several of the photographs in the original have been omitted. Some alterations in nomenclature and other minor changes and omissions are evident. If the publishers continue their admirable plan to reprint the rarer volumes in this series, the editing should be more careful.

Three families, the loons, the grebes, and the auks, puffins, murres, and their allies are included in the above volume. The author traveled to the Aleutian Islands to study the last of these families in their center of abundance. Published accounts and notes supplied by numerous correspondents have been skillfully blended with his own extensive field work into a unified, concise survey of the natural history of each species and colorful descriptions of several of the largest colonies of birds to be found in America.

D. AMADON

A CHILD'S BOOK OF BIRDS. *Pied Piper Books. Written and illustrated by Luis M. Henderson. Domesday Press, New York; [Independent News Company, New York.]* 25 cents. 32 pp. 1946.

A delightful book describing in color and in text 25 of the common birds of our fields and woodlands. This book serves as a fine introductory field guide to a 5-to 8-year old youngster who wishes to identify the bird-life of the neighborhood.

SILENT WINGS. *A Memorial to the Passenger Pigeon. Published by The Wisconsin Society for Ornithology, Madison.* $1.00 (paper). 40 pp. + 3 plates; text ill. 1947.

This brief memorial to a vanished American species will be desired by all bird-lovers and students of conservation or evolution. It contains four papers: On a Monument to the Pigeon, by Aldo Leopold; The Passenger Pigeon in Wisconsin and the Problems in Its History, by A. W. Schorger; Attitude in Conservation, by Hartley H. T. Jackson; The Great Wisconsin Passenger Pigeon Nesting of 1871, by A. W. Schorger. The illustrations include a superb color plate from the painting of a male passenger pigeon by Wm. Pope, done in 1835, together with a half-tone reproduction of Audubon's famous painting and a number of other drawings or paintings; as well as nine reproductions of photographs of the adults, egg, nest and nesting, and squab. The cover bears a drawing of the monument to the passenger pigeon, dedicated at Wyalusing State Park, Wisconsin, in May, 1947.

AUDUBON BIRDS *From the Original Water Colors in the New-York Historical Society. Hastings House Americans.*

Audubon's text with notes by Donald A. Shelley. Hastings House, New York. $1.00. 40 pp.; ill. 1946.

The naturalist who has not seen this little book of Audubon plates has a pleasant surprise in store. Here are 16 gems reproduced from the original water-colors, three of them heretofore unpublished, namely, the black-throated green warbler, the robin, and the long-billed marsh wren. These were among Audubon's earliest paintings, and were supplanted in the engravings by later efforts. The softness and lack of sharply detailed line in these pictures contrasts at once with the familiar engravings. The reproduction of color has not fared too well; the plates manifest an over-emphasis of the yellow-green which changes browns and grays into sometimes strange greens and blue-greens. The robin and the screech owl, in particular, have suffered from this. Nevertheless, the little book, with its well selected excerpts of text from Audubon's *Birds of America*, is well worth its price.

BENTLEY GLASS

THE LIFE STORY OF THE KING PENGUIN.

By G. M. Vevers; illustrated by Erna Pinner. Transatlantic Arts Company, London and New York; Pilot Press, London. 3s. 6d. 32 pp.; ill. No date.

THE LIFE STORY OF THE BEAVER.

By G. M. Vevers; illustrated by Erna Pinner. Transatlantic Arts, London and New York. 3s. 6d. 32 pp.; ill. 1946.

These two attractively written life histories of the king penguin and beaver are in language that young children can understand and enjoy. It is to be hoped that further animals will be treated in this series. The illustrations, however, while numerous and well selected for subject material, are done in a forced style that prevents them from comparing favorably with the narrative. This, however, is not a factor sufficient to reduce the general attractiveness of the books.

JOHN CUSHING

SKETCHES OF AMERICAN WILDLIFE.

By Stanley P. Young. The Monumental Press, Baltimore. $3.00. xii + 143 pp.; ill. 1946.

These rather casual sketches deal mainly with the conservation and control of various North American mammals, and are written by a man whose job it has been for many years to study and administer our generally decreasing wild life resources. In discussing the life histories, populations, depredations, etc., of mammals, the author speaks with authority, and his rambling historical notes entertain with all sorts of incidental information. The animals dealt with at length are the destructive coyotes and wolves; the rare black-footed ferret; the reintroduced musk oxen; the American antelope in its abundance, decline, and "comeback"; the prairie dog, which "lives without water"; and various fur bearers. Further essays describe the reaction of wild cats to catnip, and the voice of the puma. There are also notes on many other topics, such as the gastronomic merits of puma meat, the fuel value of buffalo chips, and the hardships of early life in the Wild West and Far North.

As an excellent field naturalist and an ardent reader of historical accounts, the author seems to have lacked time to learn much functional anatomy, yet he ventures the following crude conclusion: "A critical study of the anatomy of the puma's skull reveals several interesting characters. Foremost of these to me is with respect to the distance between the glottis and the base of the tongue. This, in most cases, is not more than an inch, or sometimes an inch and one-half. Such condition, coupled with the fact that the animal seldom is able to extend its tongue more than approximately one inch, makes possible the piercing scream as one of the vocal utterances of this animal."

A. H. SCHULTZ

MAMMALS OF NORTH AMERICA.

By Victor H. Cahalane, with drawings by Francis L. Jaques. The Macmillan Company, New York. $7.50. x + 682 pp.; ill. 1947.

This is one of those all-too-rare books of which it can be said unhesitatingly that they accomplish admirably their particular purpose. The author, chief biologist of our National Parks, has produced a popular account of all North American mammals which is authoritative, crammed with information, and so well written that it will hold the attention of the lay reader from cover to cover. The 92 delightful drawings by the talented animal illustrator, Francis Jaques, contribute greatly to the appeal of this work.

There are at least 1,500 species and subspecies of mammals living in North America to the north of the Mexican boundary and including the islands of the Arctic Ocean to the north and the various waters surrounding our continent. All of these mammals are dealt with, at least as groups, but no attempt has been made to list and identify all species and subspecies. Such information would have called for endless technical detail and is already available in such excellent works as Miller's *List of North American Recent Mammals* or Anthony's *Field Book of North American Mammals*. In this book, taxonomic treatment is limited to descriptions of the morphological characteristics of main groups and of typical species, and most the space is devoted to life histories, habits, and habitats. Terrestrial species are given more attention than marine mammals.

To all those who wrongly believe that only the life of man is filled with dramatic changes, troubles, and excitement, this volume is specially recommended. There is new information here for everybody: that bats are among the cleanest animals; that many skunks suffer from sinus trouble; that humpback whales are passionate lovers and gray whales have lice; that the fur seal bull has no time to eat during his mating season of over two months; that armadillos have migrated far northward in recent years; etc.

The volume contains a long and well selected list of references.

A. H. SCHULTZ

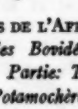
MAMMALS OF COSTA RICA. *Bulletin of the American Museum of Natural History, Volume 87, Article 5.*

By George G. Goodwin. American Museum of Natural History, New York. $2.50 (paper). Pp. 271–474 + 1 plate; text ill. 1946.

This is the first comprehensive account of the mammalian fauna of Costa Rica. It deals taxonomically with all the species known to occur in that country and with some most likely to be found there, although not yet definitely recorded. The report is based chiefly on the splendid material in the American Museum of Natural History, but it includes also other collections, mainly brought together by the late Cecil F. Underwood, to whom this monograph is dedicated. The following mammalian forms inhabit Costa Rica: marsupials are represented by 6 genera of opossums, insectivores only by shrews of one genus, pinnipeds by only one type of seal, seacows by one species of manatee, perissodactyls by two varieties of tapirs, artiodactyls by two species of peccaries and two different deers, and hares and rabbits by only one genus. The orders containing far more numerous and varied Costa Rican forms are the following: primates with 3 different families, carnivores with 5 families, edentates with 4 families, rodents with 9 families, and bats with 8 families, including 59 different genera. The grotesque heads of 50 of these bats are illustrated, but none of the other mammals are pictured.

There are comparatively few species limited to Costa Rica, but many which range with at most slight modification into Panama and Nicaragua. The mammalian fauna of the humid eastern lowlands is generally separated from that of the arid Pacific coast by forms typical of the central mountain ranges.

A. H. SCHULTZ



MAMMIFÈRES ONGULÉS DE L'AFRIQUE NOIRE. *Première Partie: Famille des Bovidés (Buffles, Antilopes, Gazelles). Deuxième Partie: Tragulidés, Giraffidés, Suidés (Phacochère, Potamochère, Hylochère), Hippopotamidés (Hippopotame), Périssodactyles (Rhinocéros), Proboscidiens (Éléphant), Hyraciens (Damans). Faune de l'Empire français, Volume II.*

By Paul Rode. Librairie Larose, Paris. (1) 130 fr. (paper). iv + 124 pp.; ill. 1943. (2) 130 fr. (paper). iv + pp. 125–211; ill. 1944.

No other continent contains as many different forms of ungulates as Africa. The present monograph gives a systematic enumeration of the great variety of ungulates that live in western and central Africa, between the Sahara and the Congo river. Much of this vast tropical region is under French administration, and these colonies are here given special consideration. The first part of the report is devoted to buffaloes, mouflons, antelopes, and gazelles, the second part to tragulids, giraffes, pigs, hippos, rhinos, elephants, and hyraxes or "coneys." The author treats all these ungulates as *one* mammalian order (no matter how difficult to define), containing four living suborders: artiodactyls, perissodactyls, proboscidians, and hyracoids. The characters described for each species are those of skin, skull, teeth, and horns, as well as some few body measurements. Geographical distribution is usually indicated only by general statements, and the notes on "biologie" are disappointingly brief, containing

at most a few bare, general remarks. The pen-and-ink drawings of skulls, teeth, and horns are clear and helpful, but many of the illustrations of entire animals are very crude. In the bibliography, one misses much of recent, non-French literature which, probably, had not been available to the author.

This taxonomic report, though most welcome and useful in many respects, does not equal the best standards of modern American mammalogy.

A. H. SCHULTZ

THE PUMA: *Mysterious American Cat. Part I. History, Life Habits, Economic Status, and Control. Part II. Classification of the Races of the Puma.*

(I) By Stanley P. Young; (II) by Edward A. Goldman. The American Wildlife Institute, Washington, D. C. $4.00. xvi + 358 pp. + 3 plates; text ill. 1946.

The puma, also known as cougar, mountain lion, panther, and catamount, has the most extensive distribution of any wild mammal of the New World, ranging from the Yukon to Patagonia, and in earlier days practically across the continent. It has been encountered at elevations of more than 14,000 feet, as well as in humid jungles at sea-level. There exist numerous geographic variations in the single species *Felis concolor*, but these warrant merely subspecific rank at most.

This thorough, monographic study dispels much of the "mystery" which has enshrouded the largely nocturnal puma in the past. The first part, by Stanley Young, describes in detail the characteristics and habits of the puma, its economic status and the hunting and control of pumas. There are also shorter chapters on "early records," the "puma in Indian lore," the present distribution of the animal, and on parasites and diseases. A surprising amount of reliable information has been brought together in these pages, which give a full account of the behavior of this large, yet rarely seen, predator. The puma's longevity, strength, voice, patience, methods of stalking and hunting, playfulness, breeding habits, litter size, gestation period, food and feeding habits, and, particularly, its stomach contents have become well known. In conclusion, the writer, a senior biologist of the U. S. Fish and Wildlife Service, pleads for the preservation of the puma wherever its presence does not conflict with the interests of livestock breeders.

The second part, by the late Edward Goldman, is devoted to the classification of the races of the puma. Thirty recent subspecies are accorded recognition, though some of these admittedly intergrade. On the basis of very extensive material and with many cranial measurements, fully recorded, each subspecies is carefully described and typical skulls are illustrated by good photographs. The dentition seems to be of little taxonomic value, but hair color is given much consideration in subspecific determinations. Individual variations, as in most wild cats, are in general not very marked. The volume closes with a very large and welcome bibliography.

A. H. SCHULTZ

COYOTES.

Written and illustrated by Wilfrid S. Bronson. Harcourt, Brace and Company, New York. $1.75. 62 pp. 1946.

Bronson's superb talent as a portrayer of natural history for children is abundantly evident in this addition to the considerable series of animal books he has already written and illustrated. His drawings are accurate and at the same time tinged with humor. The text, for six- to ten-year-olds, is well-written, straightforward natural history, a far cry from the sentimental, humanized animal stories most children are given to read. Bronson is not afraid to introduce a bit of comparative anatomy along with the relation of food habits and ways of living characterizing his subject. It is particularly gratifying to hear a word said at last, where it may do considerable good a generation from now, in behalf of this much maligned animal of North America. Like most other predators, the good the coyote does probably greatly outweighs the ill.

BENTLEY GLASS

HIDDEN ANIMALS. *A Young World Book.*

Text by Millicent E. Selsam; pictures by David Shapiro. $1.00. *International Publishers, New York.* 32 pp.; ill. 1947.

An interesting study for youngsters on protective coloration in animals. The drawings by David Shapiro are clever, and should excite the imaginative child to a keener observation of the animal world about him. An objection might be made, however, to the examples used; the ptarmigan, the sea dragon, and the trigger fish are not commonly seen, and will probably remain only examples to most readers. A wiser choice of more familiar animals would have helped the book immensely.

ECONOMIC ZOOLOGY

ANALYSIS OF POPULATIONS OF THE PACIFIC SARDINE ON THE BASIS OF VERTEBRAL COUNTS. *Fish Bulletin Number 65.*

By Frances N. Clark. State of California Department of Natural Resources, Division of Fish and Game,

Bureau of Marine Fisheries, Terminal Island. Free upon request (paper). 26 pp. 1947.

The vertebral counts on which this study is based were made by several investigators, working from British Columbia to Mexico. The counts indicate that the sardine population from British Columbia to central Lower California is mixed, and that the young found in that region may have come from any of several nursery grounds, although the nursery grounds off southern California appear to be the most important. The sardines from southern Lower California and the Gulf of California appear to comprise a distinct population, which does not mix with the northern population except for a small percentage that wanders northwards.

JOEL W. HEDGPETH

CARE AND DISEASES OF TROUT. *Research Report 12. Revised Edition, 1946.*

By H. S. Davis. Fish and Wildlife Service, United States Department of the Interior, Washington, D. C. 35 cents (paper). ii + 98 pp.; ill. 1947.

A new printing, with a modernized cover and title page, of the now standard manual for trout hatcheries. Seventy pages, by far the greatest part of this pamphlet, are given over to the various protozoan, bacterial, and fungus diseases of trout and the methods of treating these infections. The detailed information on these fish diseases should make this bulletin of interest to specialists in other fields besides the raising of trout.

JOEL W. HEDGPETH

SUCCESSFUL HAMSTER RAISING.

By Al Hayner. Bruce Humphries, Boston. $2.00. 105 pp. 1945.

This book is written by an enthusiastic and confident pioneer to help hamster raisers who have only recently become interested in their "educational, pleasant, and profitable occupation." Many things, from housing and feeding to death and a strange deodorant, are briefly considered. The book is illustrated with 26 photographs and ably executed drawings.

LADLEY HUSTED

ANIMAL GROWTH AND DEVELOPMENT

CELLULE-EMBRYOLOGIE. *Aide-Mémoire d'Histologie et d'Embryologie.*

By Jean Turchini. G. Doin & Cie., Paris. 50 fr. (paper). ii + 131 pp.; ill. 1943.

This small volume represents the first of two parts of a "memory-aid" reviewing the fields of histology and embryology. The present volume concentrates on the cell (ca. 38 pp.) and on embryology (ca. 78 pp.); the volume to follow is to consider tissues and organs.

While it is impossible in a text as condensed as the one under consideration not to resort to an occasional dogmatism or over-generalization, the presentation is in general accurate. It enjoys the added merit of being up to date. It suffers to some degree from a lack of balance in the allotment of space: some aspects of cellular chemistry, for instance, are given quite full exposition, rather than being summarily surveyed; the entire organogenesis of all the sense organs is compressed into a single paragraph six and a half lines long. The volume as a whole, however, adequately fulfills its express purpose of providing a review for students preparing for examinations.

JANE OPPENHEIMER

A LABORATORY MANUAL OF VERTEBRATE EMBRYOLOGY: *Anatomy of Selected Embryos of the Frog, Chick, and Pig. Second Edition.*

By F. B. Adamstone and Waldo Shumway. John Wiley & Sons, New York; Chapman & Hall, London. $2.00 (paper). viii + 96 pp.; ill. 1947.

The substitution of a thorough, careful study of the anatomy of certain developmental stages of the frog, chick, and pig for the more common method of drawing a few supposedly representative sections of these forms has fortunately been maintained in the second edition of this manual. This edition differs from the first primarily in that errors have been corrected and more drawing or sketching space has been provided throughout the book. The method of presentation at several places has also been improved.

N. SPRATT, JR.

ESSENTIALS OF HUMAN EMBRYOLOGY. *Third Edition.*

By Gideon S. Dodds. John Wiley & Sons, New York; Chapman & Hall, London. $4.00. xii + 314 pp. 1946.

There is definitely a place for a brief textbook of human embryology, and the printing of a third edition of Gideon S. Dodds' *Essentials of Human Embryology* is evidence that it is filling this need.

Parts wholly new or extensively rewritten for this edition include the chapters on the Early Stages in Human Development, Fetal Membranes, Early History of Mesoderm, Respiratory System, Body Cavities, Heart and Blood Vessels, Lymphatic System, Reproductive Organs, and Sense Organs. The book now consists of 286 pages of text and 27 pages of index. There is no author index, since Dodds has a stated

policy of not mentioning the names of authors or giving references. To the reviewer this seems unfortunate because it deprives the superior student of the opportunities, both to become acquainted with the great names of embryology, and to learn more about such facets of the subject as intrigue or challenge him.

For all books on anatomical subjects written since the time of Vesalius, the excellence of the illustrations has been an important criterion of usefulness. One hundred and seventy-four of the 183 figures of this textbook are line drawings and diagrams; only nine are photographs, and there are no color plates. Considering the large number of superb photographic illustrations of human and monkey material to be found in such publications as the Carnegie *Contributions to Embryology*, it is to be hoped that some can be introduced into future editions of the work.

Dodds' style is clear and understandable. His selection and treatment of the material is well balanced. However, it is difficult to avoid half truths when one attempts to condense descriptions of processes that are complex. An example of the author's occasional failure to avoid these pitfalls is his statement (p. 57) that "only a small percentage of embryos exhibit anomalies of development." Any student in a gross anatomy laboratory knows that almost every, if not every, cadaver shows at least a few minor instances of anomalous development. The impression is given (pp. 190–191) that the only cause for cyanosis in babies is a combination of failure of closure of the foramen ovale and stenosis of some of the great vessels. Again, the author says (p. 131) that "the outer cells of the dental papilla are known as odontoblasts because they secrete dentine." The consensus of dental histologists is that these cells themselves produce only Tome's fibers in the dentinal tubules.

Dodds is often very conservative in his statements, as when he says without qualification "It is not known what guides the first (nerve) fibers" (p. 232). On the other hand, there are instances when he is found at the opposite extreme. He assigns to the gubernaculum (p. 224), attached as it is to the soft pliable skin of the scrotum, at least partial responsibility for the descent of the testis into the scrotum. The work of Wells (1944) appears to point to a different mechanism of testicular descent.

A volume of this size is certainly no place for an extended discussion of physiological aspects of development, but still an embryology written for the medical student might include with profit brief discussions of the more recent information on such topics as the function of the placenta, fetal respiration and metabolism, the dynamics of circulation, renal physiology, and the effects of hormones on the fetus. This criticism is, of course, even more cogent in the case of the larger embryology texts which are in current use.

The weakest chapter of the book seems to be the last, in which there is a general discussion of anomalies and their causation. Dodds' statement "that the great majority of mammalian monsters are very probably due to an insufficient oxygen supply during development, and that this condition, as a rule, is due to faulty placentation" (p. 286) is not in agreement with conclusions arrived at by recent students of the subject (cf. Murphy's conclusion in 1940 that "gross human congenital malformations arise solely from influences which affect the germ cell prior to fertilization"). Likewise his generalization that "not many anomalies . . . seem to be of the hereditary type" (p. 285) disagrees with those of such students of the question as Streeter and Macklin.

A minor criticism regarding style includes the use of such terms as the redundant "consensus of opinion," "spinal chord," "doubtless" (in cases in which considerable doubt exists), "purpose" instead of the nonteleological term "function," and "alternate to" for "alternate with."

JAMES A. MILLER

GROWTH OF MAN. *Tabulae Biologicae, Volume XX. By W. M. Krogman. Dr. W. Junk, Amsterdam.* f 70.—(paper). vi + 963 pp. 1941.

The author of this bulky work has gained the gratitude of his colleagues in physical anthropology and of pediatricians by having undertaken the laborious task of compiling the most significant data from the recent literature pertaining to the quantitative growth of man both before and after birth. This volume serves as a useful guide to and abstract of the vast, varied mass of studies on human growth. It offers no conclusions and has only a very brief foreword. From the latter one learns mainly that this report covers the period between 1926 and 1938, having been completed in September of the latter year. The comparable data which had accumulated prior to 1926 had already been collected by Martin and Bach in an earlier volume of these *Tabulae*.

The author has selected what he considered to be the most useful information regarding quantitative aspects of human growth, and has reprinted such data in the form of original tables or curves, including the captions in the original language, though with a general title in English. The material is arranged under the following main headings, which reflect the many-sided interests represented in the investigation of the growth of man: growth during foetal life; growth from birth to two years; growth from two years to adult (grouped in geographical subdivisions); ossification; cranial growth and growth of face and paranasal sinuses; calcification and eruption of teeth; brain growth; visceral growth; body surface and volume; vital capacity; circumferences and tissue thickness; constitutional types; physiological functions; and environmental factors in growth. By

far the largest single chapter deals with the anthropometric features of Growth from Two Years to Adult. A very considerable share of the tables collected here is by no means self-explanatory, but will necessitate consultation of the sources for full understanding of the information given. The technical explanations, if reproduced at all, are often inadequate. The all-important list of references has been printed in a rather miserly fashion and quite out of proportion to the great service to be expected from this vital information, which, though now assembled, is difficult to use. The subject index could have been more detailed for a work of this sort.

Every library of physical anthropology and of pediatrics must have this volume. It will be indispensable to all students of human growth.

A. H. SCHULTZ

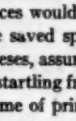
BRAIN AND BODY WEIGHT IN MAN: THEIR ANTECEDENTS IN GROWTH AND EVOLUTION. *A Study in Dynamic Somatometry. Annals of The New York Academy of Sciences, Volume XLVI, Article 10.*

By Earl W. Count. The New York Academy of Sciences, New York. $2.00 (paper). Pp. 993-1122. 1947.

The lengthy title of this study, which contains 78 pages of text, indicates that it represents a new attack on the old problem of the correlation between brain weight and body weight in ontogeny and in phylogeny. The fresh attack is made by a logarithmic analysis of data, gathered entirely from the literature, although only a part of the pertinent, available data have been used. The author seems to be aware of the fact that brain and body weights, as recorded (with sometimes doubtful determination of species) by different collectors from fresh or preserved, wild-shot or captive, and healthy or diseased specimens, are notoriously lacking in comparability. He admits that the data he uses "may be far from uniform in quality or quantity, but one thing is certain: when they are put through a process, they do tell a story." The reader who wants to learn that redeeming process will have to consult the involved chapters on Orientation, Standpoint and Method, and Principles and Terminology, which cannot be condensed into a brief review and from which only one warning sentence may be quoted: "The ways of the mathematical country are very unexpected, and the traveler finds himself unequipped for rough going." The author's process has resulted in 15 "stories" or conclusions of which only the final, culminating one can here be quoted in part: "When, finally, ontogenetic growth and comparative-anatomy lines are compared, as far back as the former can be traced in the materials at hand, a certain parallelism exists between fetus and comparative anatomy. The fetal line, however, tops the comparative-anatomic, in such a way that a fetus of a given body size always has a heavier brain than some extant adult relative of equal body size, who presumably is less evolved. In the primates, this preponderance is much greater than in any other line."

There is an appendix of 31 tables of raw data, ratios, and coefficients, and of 24 logarithmic curves, etc., everything being based on data by others. It seems that reference to sources would have sufficed in many cases and would have saved space for support of the author's many hypotheses, assumptions, and principles, of which he says with startling frankness: "I have more confidence in the scheme of principles set forth herein than in any of the concrete numbers that have served to bring them out."

A. H. SCHULTZ



ANIMAL MORPHOLOGY

AN INTRODUCTION TO VERTEBRATE ANATOMY. *Revised Edition.*

By Harold Madison Messer. The Macmillan Company, New York. $4.75. xxii + 475 pp.; ill. 1947.

The author's purpose in writing this text was to provide "a book containing a minimum amount of material" for a one-semester course. The present edition has been corrected and somewhat enlarged, but the whole has been kept within easily manageable bounds. It presents a large mass of important, accurate, and up-to-date facts, well organized by organ systems. The student who masters the material to be found here will undoubtedly be well grounded in the facts of comparative vertebrate structure. The style is clear, and the illustrations are numerous and well chosen. Many of them are original, although most are old familiars of the "from-Wilder-after-Kingsley" variety. It is a pity that the numerous and intrinsically handsome and instructive plates in the chapter on the taxonomy of the vertebrates are printed on such poor paper that they appear faded and worn.

The reviewer's experience in teaching comparative anatomy leads him to wish that the handling of theory had been considerably bolder. Adaptation is mentioned briefly, two or three times, but is nowhere explicitly discussed. The same is almost as true of homology. Yet these are two of the most central concepts in the entire field of comparative anatomy! Furthermore, they are both topics on which the average student's mind is full of the most atrocious nonsense. No doubt the users of this textbook will cover this kind of material in lecture. However, space for it could be found in the text by the deletion and condensation of less relevant material, e.g., the section on meiosis (which is out of date anyway), or the portion con-

cerning the comparative anatomy of sperms and the intimate details of the hen's egg.

GAIRDNER MOMENT

ATLAS OF OUTLINE DRAWINGS FOR VERTEBRATE ANATOMY.

By Samuel Eddy, Clarence P. Oliver, and John P. Turner. John Wiley & Sons, New York; Chapman & Hall, London. $2.00 (paper). viii + 80 pp.; ill. 1947.

This manual replaces the *Atlas of Outline Drawings of the Dogfish Shark, the Necturus, and the Cat for Vertebrate Anatomy* by the same authors. It is essentially the same book, with some worthwhile modifications. *Amphioxus* has been added to the forms represented, the skulls of three "ganoids" are given for those who wish to study the dermatocranium, and various additions and modifications have been made in the case of those species found in the original volume. Users with a real taste for the comparative aspect of comparative anatomy will be especially pleased by the addition of the hypobranchial skeleton for the amphibian and the cat.

As one who uses this manual in teaching, the present reviewer is convinced that, along with the increase in detailed accuracy of the drawings in the present volume, there grows an increased need for devices that will insure training in rigorous and independent observation. This need becomes more acute as classes become larger. A series of blanks for simple original drawings of carefully selected structures or structural relationships would greatly enhance the teaching value of a subsequent edition. There would not need to be many such original drawings, nor need they be difficult, purely from a draftsman's point of view.

GAIRDNER MOMENT

ANIMAL DRAWING AND PAINTING. *Creative Arts Library.*

By Walter J. Wilwerding. Watson-Guptill Publications, New York. $6.00. xviii + 147 pp.; ill. 1946.

With this richly illustrated volume the author does not intend to provide copy material for illustrators, but to show by means of well chosen examples and by systematic comment how animals may be drawn or painted with accuracy and beauty from life. For success, the author recommends that you "learn to draw and paint well" and "develop the persistence to study everlastingly the animals you intend to paint." Throughout the text, the beginner will find valuable hints on how to draw and paint and in two final chapters, on "How a Picture is Made" and "Some Studio Practices," he will find instructive comments on composition, simplicity, point of view, paints, varnishes, canvas, brushes, and even on "friendly critics." The main and most original part of the book, however, is devoted to the many problems involved in observing animals accurately and in reproducing these observations faithfully. The author draws on his own varied experiences in discussing the character of many animals according to age, sex, and, sometimes, season. He illustrates excellently many types of animals in action and in repose, showing convincingly that every detail should be studied in order to avoid drawing taxonomic errors or anatomical impossibilities. The author's skill in observation and his painstaking devotion to probing all the outer characters of animals is most apparent in his fine chapters on hair texture, direction, and color, and on the detailed construction of heads, ears, feet, etc. The chapter on "Anatomical Considerations" is probably too brief and too generalized, but the well-proportioned, clear drawings of skeletons and of the main superficial muscles recognizable on living animals, are bound to be helpful to the art student. The book is mostly concerned with mammals, wild and domestic; birds are given some attention; but other animals are hardly mentioned.

The great majority of the sketches and half-tone illustrations are by the author himself, whose art will appeal specially to animal lovers and to mammalogists on account of the splendid characterization and remarkable attention to detail, evident in every figure. In addition the volume contains notes on numerous other animal artists, as for instance Rungius, Bransom, Knight, Jacques, Fuertes, and Mauve, with examples of their work, well reproduced though without color, like all the other illustrations.

A. H. SCHULTZ

ANIMAL ANATOMY AND PSYCHOLOGY *for the Artist and Layman.*

By Charles R. Knight. Whittlesey House, McGraw-Hill Book Company, New York and London. $5.00. viii + 149 pp.; ill. 1947.

In a final chapter of this book its well-known artist-author says: "To see is to know, and to . . . see accurately is to put into the mind and hand of any artist the greatest power of expression of which he is intellectually capable." This unique volume is an enthusiastic, splendid guide to the art of really seeing live animals, of seeing how their constructions and their emotions influence their appearance, and how the latter can be reproduced accurately, characteristically and—by emphasizing essentials—artistically. The skeletons, proportions, main muscle masses, chief postures, and actions of many different types of mammals and of some birds are discussed from the point of view of the artist of animals. There are also brief chapters on reptiles,

fishes, and invertebrates, and special essays on such topics as How Animals Lie Down, Hair Tracts, Wings, Young Animals, etc. The text, naturally, contains much information that is not new to zoologists, but also many incidental observations by a great expert in "seeing" which are well worth further study. The text, however, is greatly surpassed in value to scientists and laymen alike by the 123 magnificent illustrations, masterfully drawn, perfectly reproduced, and each one worth framing. The plate of Tiger Heads in Repose and Action alone is worth the price of the book, which will be an ideal Christmas present to any animal lover. To the reviewer, the drawing of a tiger skull by Knight gives more pleasure than the possession of the specimen itself would. The sketch of a lion's head on the frontispiece is a shining example of perfect craftmanship, that should inspire (or lead to despair) any scientist who ever struggled with his own illustrations. Let us hope that more samples of the great work of the master of animal portraiture, Charles Knight, will become available in equally perfect and accessible form!

A. H. SCHULTZ

ARTISTIC ANATOMY. *Revised Edition.*

By Walter Farrington Moses. Borden Publishing Company, Los Angeles. $3.95. vii + 64 pp. + 57 plates. 1947.

According to the preface, this atlas "has been especially prepared for the beginning student as well as for the advanced artist," and the author has endeavored "to achieve a work with the thoroughness of a surgical anatomy, yet especially adapted to the needs of the artist." Actually, the book merely illustrates and labels the skeleton and most of the muscles of a standardized adult human body in different aspects, and with very much and quite needless repetition. The drawings are rather crude and can certainly not be called artistic. The anatomical explanations are often also crude or even erroneous. To mention only a few of many such instances: Of the palmaris longus muscle, it is stated in one place that it "stretches the palm" and in another place that it "extends and adducts the wrist"; the platysma is claimed to be "originating in the clavicle inserting into the lower jaw-bone"; the pelvis is referred to as "a bony cavity . . . composed of four bones, two hip bones on each side and two behind"; the thoracic vertebrae are defined as "the twelve bones which form the trunk"!

Fortunately there exist already many good "anatomies" for artists, so that there is no excuse for the present volume, which is neither artistic, nor good anatomy, nor anywhere nearly comprehensive enough for the needs of serious art students.

A. H. SCHULTZ

THE THORACIC MUSCLES OF THE COCKROACH PERIPLANETA AMERICANA (L.). *Smithsonian Miscellaneous Collections, Volume 107, Number 2. Publication 3890. By C. S. Carbonell. Smithsonian Institution, Washington, D. C.* 20 cents (paper). ii + 23 pp. + 8 plates. 1947.

ANIMAL PHYSIOLOGY

THE PHYSICO-CHEMICAL MECHANISM OF NERVE ACTIVITY. *Annals of The New York Academy of Sciences, Volume XLVII, Article 4.*

By David Nachmansohn, Charles M. Berry, Oscar Bodansky, Frank Brink, Jr., Detlev W. Bronk, M. Vertner Brown, C. W. Coates, R. T. Cox, J. C. Eccles, Alfred Fessard, J. F. Fulton, R. W. Gerard, Alfred Gilman, D. E. Green, Joseph C. Hinsey, Rudolf Höber, Martin G. Larrabee, and Tracy J. Putnam. The New York Academy of Sciences, New York. $3.00 (paper). Pp. 375-602 + 5 plates; text ill. 1946.

This is a printing of the proceedings of a conference held by the Section of Biology of the New York Academy of Sciences on February 8 and 9, 1946. It is a publication which is notable for its scope and the generally high calibre of the papers presented. The contents and contributors are as follows: Introduction, Tracy J. Putnam; The Membrane Theory, Rudolf Höber; Chemical Mechanism of Nerve Activity, David Nachmansohn; An Electrical Hypothesis of Synaptic and Neuro-Muscular Transmission, J. C. Eccles; Chemical Excitation of Nerve, Frank Brink, Jr., D. W. Bronk, and Martin G. Larrabee; Electric Characteristics of Electric Tissue, R. T. Cox, C. W. Coates, and M. Vertner Brown; Some Basic Aspects of the Activity of Electric Plates, A. Fessard; Physiological Function from the Standpoint of Enzyme Chemistry, D. E. Green; Cholinesterase, Oscar Bodansky; The Effects of Drugs on Nerve Activity, Alfred Gilman; The Recovery of Diameter and Impulse Conduction in Regenerating Nerve Fibers, Charles M. Berry and Joseph C. Hinsey; Nerve Metabolism and Function, R. W. Gerard; Conclusion, J. F. Fulton.

Although valuable information and ideas abound in these various papers, it seems to this reviewer that some are more outstanding than others. For clarity, scope, and interpretation of their subjects, the articles by Höber and by Fessard are noteworthy. The reader is indebted to Nachmansohn for a systematic statement of his views. Standing alone, they make a convincing story in which the case for an acetylcholine-cholinesterase system in nerve excitation and conduction seems established. Then, when confronted with the objective account of almost classic experiments by Brink et al., one begins to doubt the role of acetylcholine in nervous action. This is increased still further by

Gilman's description of the continuance of conduction after cholinesterase has been eliminated from nerve by means of DFP. The verbal onslaught upon Nachmansohn's thesis by Gerard, however, causes one to be cautious again. Gerard says, with respect to acetylcholine and nerve conduction that "this hypothesis has now exhausted its usefulness." One would agree, on the basis of this book, that the concept of the role of acetylcholine as a mediator of nerve conduction is not as it was thought to be. But certainly no one will disagree with the restraint of Nachmansohn when he says that "the precise function of the (cholin) ester is still a matter of interpretation.... A number of questions still have to be answered before a satisfactory picture of the chemical mechanisms of nervous action can be obtained."

S. R. M. REYNOLDS

THE SCIENCE OF SEEING. *Pelican Books.*

By Ida Mann and A. Pirie. Penguin Books, Harmondsworth, Middlesex. 1s. (paper). 220 pp. + 7 plates; ill. 1946.

This is an interesting little book—different from most on the eye. Its primary aim is to provide the layman with an understanding of how his eyes work and of the kinds of things that can go wrong with them. In accomplishing this aim, the authors dispel a number of popular misconceptions about ophthalmology—misconceptions which one finds even among biological scientists. The reader will learn, for example, (1) the difference between an optician and an ophthalmologist, (2) that eye-glasses do not "weaken" or "strengthen" his eyes, (3) that "eye-strain" is not a retinal defect, and many other things he ought to know. It is gratifying that two authorities in the field have taken the time to clarify a number of these points.

The first half of the book is an elementary discussion of the anatomy and physiology of the eye. The authors use a comparative approach in this discussion and show how the eye has developed in different species. This approach enables them to point out that certain abnormal deviations of the human eye are normal for other species of animals and are biologically adapted to their particular environments. The second half of the book deals with visual defects, facts and fallacies about ocular hygiene, and blindness. The final chapters on blindness are mainly concerned with the care and treatment of ocular injuries and blindness in England under the National Health Insurance system. These sections will probably be interesting to an American audience only as an example of how a group insurance plan operates in another country.

Because of its orientation, this is an elementary treatise. The visual scientist will find in it little or nothing that is new to him. But the layman who is curious about his eyes will certainly enjoy it and profit from it. The authors' style of writing is free and easy; the book reads almost like a novel. Certain expressions—"Now you come to the iris, which is fraught with interest and charm"—will seem odd to an American audience, but they are easily overlooked.

A. CHAPANIS

ANIMAL NUTRITION

SCIENCE AND NUTRITION. *Second Edition.*

By A. L. Bacharach, with a preface by Sir J. C. Drummond. Watts & Company, London. 5s. xii + 142 pp. 1945.

Bacharach is a nutrition investigator of distinction and is eminently qualified to tell in non-technical language the story of those fundamental researches which have yielded so many remarkable discoveries concerning the nutritive needs of the body, the constituents of our foodstuffs, and their significance for health. It is the story of research which brought to light the causes of beriberi, scurvy, rickets, pellagra, simple goiter, and a dozen other less well-known disorders that are due to specific dietary deficiencies. In 140 pages the author has discussed: the use of animal experiments; the major food constituents; carbohydrates; carbohydrates in the body; the chemistry of fats; fats in the body; the chemistry of the proteins; the amino-acids in the body; the major mineral elements; hormones—iodine; trace elements; vitamins in general; detecting vitamins; measuring vitamins; identifying vitamins; deficiency diseases; diet and human health; the necessity for the optimal; the absence of the optimal.

Bacharach has succeeded well in telling the research story—the results obtained and the methods used, especially those carried out under laboratory conditions, that have influenced our views of the relationship between human nutrition and health.

E. V. MCCOLLUM

FOOD AND NUTRITION: *The Physiological Bases of Human Nutrition.*

By E. W. H. Cruickshank. A William Wood Book, The Williams & Wilkins Company, Baltimore. $4.50. viii + 326 pp. + 20 plates. 1946.

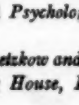
The author is Regius Professor of Physiology in the University of Aberdeen. In the compass of 125,000 words, the author has discussed: the evolution of dietaries; the problem of world nutrition; the problem of nutrition in Great Britain; the problem of nutrition in Great Britain during the war years 1939–45; the energy requirements of the body; protein requirements of the body; foodstuffs and their fuel values; mineral salts in

nutrition; vitamins and dietary deficiency diseases; bread; milk; protein-rich foods; vegetarianism; dietary standards and dietary planning; dehydration and preservation of foods; diet and dental caries, the appraisal of nutritional status in individuals and communities; and, finally, the Food and Agriculture World Organization.

Obviously, in a book of this size, which attempts to cover so many subjects, the discussions must be rather sketchy. The book is well written and makes entertaining reading. Its mission will be to educate the intelligent layman as to the nature of human nutrition problems, their magnitude, and their geographical distribution. For this purpose the book is excellent. At the end of each chapter there is a select bibliography of those works on which the book is based. Most of these references will not be available except to those who have access to a good scientific library.

Readers may question why the author has devoted space to the details of the techniques for determining the calorie value of foods and for estimating the basal metabolic rate, and why figures and a flow-sheet describing the construction and operation of a milk pasteurization plant were included. These seem to be quite out of place, since readers who would profit by the rest of the book would not generally need the details of analytical or technological methods. Space is also devoted to describing what a veterinarian does in examining dairy herds for reactors to tuberculosis. Also, for an American edition, the Special Designations of the British Ministry of Health for market milks of different quality seem quite out of place. They might with advantage have been replaced by information about market milks in this country.

E. V. McCollum



MEN AND HUNGER: *A Psychological Manual for Relief Workers.*

By Harold Steere Guetzkow and Paul Hoover Bowman. Brethren Publishing House, Elgin, Illinois. $1.00. 72 pp.; ill. 1946.

In anticipation of a need for more knowledge of the effects of starvation on man, the Church of the Brethren, the American Friends Service Committee, the Mennonite Central Committee, the Unitarian Society, the John and Mary Markle Foundation, the Sugar Research Foundation, and the National Dairy Council, jointly, sponsored a study at the University of Minnesota under the able supervision of Ancel Keys. The study was based upon voluntary semi-starvation by 32 young men. They were first studied systematically for three months under normal conditions and then were semi-starved for a period of six months, losing about 25 per cent of body weight. They were then rehabilitated for three months.

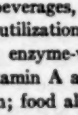
The report of the study, contained in this little book, is a highly important contribution to our knowledge of one of the most widespread and difficult of human problems: the effects of starvation over a considerable period. It supplies a key to the understanding of psychological problems in relation to physiological need. Here it is shown that the semi-starved person fits a characteristic picture anywhere, and that emotional and personality states are uniform to an uncommon degree. The book cannot be too highly recommended to all who are sensitive to humanitarian or religious impulses, and it must arrest the attention of everyone who would seek to assist in solving the world's sociological, economic, and industrial problems. To quote a statement from the sponsors: "Many of the so-called American characteristics—abounding energy, generosity, optimism—become intelligible as the expected behavior response of a well-fed people. There is but one way by which to secure these desirable human qualities in peoples the world over." The results of this study should strengthen the determination of thinking people to leave nothing undone to solve the international food problem.

E. V. McCollum

NUTRITIONAL CHARTS: *Prepared expressly for medical, dental, and dietetic specialists. Twelfth Edition.*

By the staff of the Research Department of H. J. Heinz Company, Pittsburgh. Gratis (paper). 48 pp. 1946.

This publication contains 23 nutritional tables of great usefulness, summarizing: daily quantities of nutrients suggested for individuals of various sizes; the nutritional characteristics of food classes; clinical criteria of deficiency disease symptoms; conditioned malnutrition; vitamin data; mineral nutrients; composition of vegetables, fruits, cereals and bakery products, meats, fish, and poultry, nuts, beverages, dairy products, and miscellaneous foods; utilization of foodstuffs; intermediate metabolism; enzyme-vitamin relationships; vitamin inhibitors; vitamin A and vision; enzymes in digestion and nutrition; food allergies; and of course, the nutritive values of Heinz Products and Heinz Baby Foods. The tabular arrangement makes reference easy and an amazing amount of valuable information is provided.



BIOCHEMISTRY

PRACTICAL PHYSIOLOGICAL CHEMISTRY. *Twelfth Edition.*

By Philip B. Hawk, Bernard L. Oser, and William H. Summerson. The Blakiston Company, Philadelphia and Toronto. $10.00. xiv + 1323 pp. + 5 plates; text ill. 1947.

This is an extensive revision of the earlier edition by Hawk and Bergheim. Most of the chapters have been either rewritten completely or extensively revised. Much new material has been added, including sections on the polarograph, isotopes, antibiotics, photometric analysis, and many new quantitative procedures for blood and urine analysis. Many new figures, graphs, and tables are included. The present edition of this widely used text and reference book will be received enthusiastically by various workers in physiological chemistry and its related fields.

W. D. McElroy

Advances in Carbohydrate Chemistry. *Volume 2. Edited by W. W. Pigman, M. L. Wolfrom, and Stanley Peat. Academic Press, New York.* $6.60. xiv + 323 pp. + 1 plate; text ill. 1946.

In founding the *Advances in Carbohydrate Chemistry*, it was the purpose of the editors to furnish critical and integrating reviews of the field of carbohydrate chemistry and to present them "in such a form as to be intelligible to the average chemist rather than only to the specialist." These avowed objectives are admirably fulfilled in the first two volumes. Volume II maintains the high standard of thoroughness and usefulness initiated in the first volume. There is every reason to believe that the continuation of these reviews will provide a comprehensive and accurate representation of the changing and growing field of carbohydrate chemistry and serve as a stimulus to its further development.

The review on Melezitose and Turanose, by C. S. Hudson, is written in the usual lucid style characteristic of that eminent author. It is a complete account of the naturally occurring trisaccharide, melezitose, and of the disaccharide turanose, which is obtained as a product of hydrolysis of the trisaccharide. The reasoning involved in deriving the structural configuration of these sugars, based on the data of the author as well as those of other workers, is presented with utmost clarity. A scholarly article on the Chemistry of Anhydro Sugars is presented by S. Peat. He considers the sugar anhydrides according to the size of the anhydro ring and discusses them under the following three classifications: ethylene oxide type, hydrofuranol or butylene type, and glycosen type. The compilation of all the known anhydro sugars in table form, giving their properties and those of their derivatives, constitutes a very useful feature of the review.

Under the topic of Analogues of Ascorbic Acid, Fred Smith gives an excellent discussion of the methods of synthesis of analogues of l-ascorbic acid and of their physiological activity and structure.

Synthesis of Hexitols and Pentitols from Unsaturated Polyhydric Alcohols, by R. Lespieau, is chiefly a description of experimental details for the preparation of a number of these alcohols, based primarily on the author's own work. Inasmuch as there is very little information regarding this subject, this article is a very welcome contribution.

The treatment of the chapter on The Interrelation of Carbohydrate and Fat Metabolism, by Harry J. Deuel and Margaret G. Morehouse, is purely biochemical in nature. It is concerned chiefly with the interconversion of these substances in the animal cell. M. Stacey does great justice to the complicated subject entitled The Chemistry of Mucopolysaccharides and Mucoproteins. As this author points out: "This field not only covers carbohydrate and protein chemistry, but the area lying between the two, and also it borders on the lipid field." The articles on Bacterial Polysaccharides, by Taylor H. Evans and Harold Hibbert, The Chemistry of Pectic Materials, by E. L. Hirst and J. K. N. Jones, and The Polyfructosans and Difructose Anhydrides, by Emma J. McDonald, are somewhat similar in plan and treatment to the previous article.

Joseph F. Haskins' review of Cellulose Ethers of Industrial Significance is an account of the development of cellulose ethers and their importance in commercial developments.

Advances in Carbohydrate Chemistry is a welcome example of international scientific cooperation. Of the 10 articles in the present volume, four are from authors in the United States, four come from Great Britain, one from Canada, and one from France.

W. Z. Hassid

Advances in Protein Chemistry. *Volume III. Edited by M. L. Anson and John T. Edsall. Academic Press, New York.* $7.50. xii + 524 pp.; ill. 1947.

The present volume, like the previous ones in this series, contains critical reviews by workers in protein chemistry and related fields. In general, the articles are well written and contain excellent bibliographies.

Contributions from abroad include articles by Alexander E. Braunstein on "Transamination and the Integrative Functions of the Dicarboxylic Acids in Nitrogen Metabolism" and by Arne Tiselius on the techniques developed in his laboratory for the "Adsorption Analysis of Amino Acid Mixtures."

Paul L. Kirk reviews the various techniques used in "The Chemical Determination of Proteins," and an article by Max S. Dunn and Louis B. Rockland is concerned with "The Preparation and Criteria of Purity of the Amino Acids." Roger M. Herriott discusses the various "Reactions of Native Proteins with Chemical Reagents."

Two articles dealing with protein films are included;

the first, by Henry B. Bull, is on "Spread Monolayers of Proteins," and the second, by Alexandre Rothen, deals with "Films of Protein in Biological Processes." Leonor Michaelis reviews "Ferritin and Apoferritin." Robert Elman discusses "The Use of Protein and Protein Hydrolyzates for Intravenous Alimentation," and Anthony A. Albanese reviews "The Amino Acid Requirement of Man." The final article, by John T. Edsall, is an extensive discussion of "The Plasma Proteins and Their Fractionation."

An author and subject index is included.

W. D. McElroy

Methods of Vitamin Assay.

Prepared and edited by The Association of Vitamin Chemists, Inc. Published for The Association of Vitamin Chemists, Inc., by Interscience Publishers, New York and London. $3.50. xviii + 189 pp. 1947.

The present book represents the combined efforts of a group of scientists who organized in the Chicago area, in 1943, an association for the "purpose of promoting: (1) the exchange of information on methods of vitamin analysis for specific food, feedstuffs, and pharmaceutical products; (2) the consideration of means of improving vitamin methods from the standpoint of cost, simplicity, and optimum correlation with the vitamin requirements of man; and (3) a better interpretation of the significance of vitamin values, as determined by various methods." The various methods which are described represent the combined efforts of a committee which was appointed for each of the vitamins. Likewise, the published procedure for certain types of assays have been modified and many useful techniques and short cuts have been presented in accordance with the experience of the writers. At the present time, the book is limited to those methods which several committee members have successfully applied to a variety of foods and other materials. The methods for assaying the following vitamins are included: vitamin A, carotene, thiamine, riboflavin, niacin, and ascorbic acid. Bibliographic references to assay methods for the other vitamins are included.

In describing the various procedures, the authors have assumed in the reader the background of a laboratory technician, with limited training in quantitative analysis. The quantity and type of equipment, the various reagents and methods of preparation, and the procedure of the assay are given in great detail. The method of preparing the sample for assay is given for several representative types of material. The chapter concerned with sampling for vitamin analyses and that regarding the use of check samples in the control of vitamin methods are to be recommended for all readers, whether they are primarily interested in vitamin assay, in the growth requirements of organisms, or in the determination of pH.

The book should be very useful to the various workers concerned with vitamin assays, and it is hoped that future revisions will include the assay methods of the remaining vitamins. Extensive modifications and altogether new procedures for the assay of various vitamins may be expected to call for an early revision of certain sections.

W. D. McElroy

The Interaction of Drugs and Cell Catalysts. *Revised Edition.*

By Frederick Bernheim. Burgess Publishing Company, Minneapolis. $2.25. vi + 107 pp. 1946.

The present edition, similar to the first, is divided into two parts, dealing with: (1) drugs which affect the activity of certain enzymes; and (2) drugs which are acted on by certain enzymes. Almost half of the first part is concerned with choline esterase activity and the effects of various agents on this system. These data are then correlated with the effects of these drugs on various mammalian systems (e.g., cardiovascular, nervous system, etc.). In the remainder of the first section the author considers the effects of essential elements, toxic metals, cyanide, fluoride, phlorizin, dinitrophenol, sulfanilamide, anesthetics and hypnotics, and caffeine on mammalian organisms and tissues. No consideration is given to the many studies which have been conducted on organisms other than mammals. The second section is concerned primarily with the mechanisms by which certain drugs are inactivated or removed by the body.

W. D. McElroy

Chemistry and Methods of Enzymes. *Second Edition.*

By James B. Sumner and G. Fred Somers. Academic Press, New York. $6.50. xii + 415 pp. 1947.

The general plan of presentation followed by the earlier edition of this well-known book on enzymes has been essentially maintained in the present edition. New material has been added to bring the various sections up to date. Many of the chapters concerned with the various phases of carbohydrate metabolism have been completely rewritten. The present edition certainly achieves its purpose in presenting a general survey of enzyme chemistry to the research worker and advanced student. For a more comprehensive and detailed treatment of the subject the authors have included over 1800 references to the original literature.

W. D. McElroy

LES ISOTOPES RADIOACTIFS EN BIOLOGIE.
By André Strohl and Michel Berger. Masson et Cie., Paris. 240 fr. (paper). iv + 124 pp. 1946.

The application of isotopes to biology is beginning to burgeon in France, the land in which artificial radioactivity was discovered. After a lag due to the late War and the straitened economy attendant in its wake, it is encouraging to note the increasing French literature in this field. The present article is an extensive review of applied isotopy in biology, with major emphasis upon the fields of physiology and medicine. The writers have provided remarkably adequate coverage of the literature up to 1945 considering the erratic availability of scientific journals in France.

The first two chapters are given over to a simplified general discussion of nuclear structure and tracer methodology. The writers have chosen to adopt an enthusiastic and not too critical attitude in these chapters. Thus they state that in elucidating thyroid metabolism (p. 45) one can extract, measure activity, and study reaction-chains involving the well-known intermediates of thyroid metabolism with no difficulty. While this statement is partially true, it may give the reader a false impression about the accessibility of all metabolic problems to the tracer method. However, in a review of this type it is probably out of place to display dirty wash.

The final chapter devotes a short and cursory review to a large number of studies chosen to illustrate "the principal results." For this purpose studies in phosphorus, iodine, and iron metabolism have been stressed. This choice was partially motivated by the medical interest in studies of blood cell metabolism and thyroid function. Such studies lead directly to considerations of the impact of tracer methods on therapy. The authors do not include a section on studies with tracer carbon, probably because most of this work has been done with stable carbon isotopes. As is inevitable, some outmoded material has been included, such as work on phosphate turnover in muscle which was vitiated some time ago because of one of the hazards in tracer work not mentioned by the writers in their general discussion namely, the lack of isotopic equilibration between administered labeled substrate and the same unlabeled material present *in vivo*. Nevertheless, a wealth of material has been made conveniently accessible in this volume, and there is no doubt that the efforts of the writers will lighten the task of their French biological colleagues in entering the field of applied isotopy.

MARTIN D. KAMEN

RADIOACTIVE TRACERS IN BIOLOGY: *An Introduction to Tracer Methodology. Organic and Biological Chemistry, Volume I.*
By Martin D. Kamen. Academic Press, New York. $5.80. xiv + 281 pp.; ill. 1947.

With the advent of radioactivity in recent years, a new valuable tool became available for the study of physical and biological problems. Employing radioactive tracers, considerable progress has already been made in the last decade in studying problems which hitherto could not have been attacked by ordinary chemical methods. Since the recent release of radioactive isotopes by the U. S. Government to American scientists, biological research especially has received a great impetus. At the present time the biochemist has available, for his investigations, isotopes of every element of biological interest. However, the rapid strides which the science of nuclear physics has made in recent years have created an unavoidable lag in the transmission of the new knowledge to workers who are not specialists in the field. In his book *Radioactive Tracers in Biology*, Kamen has successfully presented the accumulated unassimilated knowledge to the biologist in a more digestible form, emphasizing particularly tracer methodology as applied to biological research.

The first three chapters are devoted to a review of the concepts of nuclear physics, which are essential to the intelligent application of tracer methods in biology. Here we find a lucid and brief non-mathematical treatment of nuclei and nuclear reactions that is within the grasp of the biologist who has the usual background in the physical sciences.

Chapter 4 deals with procedures for radioactive assay, which include an explanation of the underlying principles of the Geiger-Mueller counter and other radiation detection instruments. It also contains a description of manipulations and methods used in tracer experimentation, intended to provide a basis for the acquisition of the skill required in researches with radioactive isotopes.

Chapters 5 through 10 are concerned with biological work done with the most important radioactive isotopes, H^3, C^{11}, C^{14}, P^{32}, and S^{35}. The section on tracer methodology is particularly valuable in explaining the types of problems which can be attacked by the use of tracers. Here the potentialities and advantages, as well as the limitations, of the tracer technique are discussed. The author presents experimental data with accompanying analyses and interpretations of what he considers the most important works in the field.

The subsequent chapters are devoted to work with radioactive isotopes of somewhat lesser importance in biological work, such as alkali metals, alkaline earth elements, halogens, etc., and concludes with a survey of special topics dealing especially with techniques applicable to radiation therapy.

The book contains a great number of useful graphs, charts, and tables, and an extensive well-chosen bibliography. Although it is intended primarily for the biologist, chemists and even physicists will undoubt-

edly find this book a valuable addition to their libraries.

W. Z. HASSID

RAW MATERIALS FROM THE SEA.

By E. Frankland Armstrong and L. Mackenzie Miall. Chemical Publishing Company, Brooklyn, New York. $3.75. xiv + 196 pp.; ill. 1946.

This book could have been much better. As a short treatise on the methods of extracting various salts and elements from seawater, it should be useful enough for industrial chemists, but the chapters on oceanography and the biochemistry of the oceans leave much to be desired. The authors appear to have consulted miscellaneous sources down to 1944, but missed the most important recent works on oceanography. Their major source was the symposium volume published by the National Research Council in 1932, while the standard text by Sverdrup, Johnson, and Fleming (1942) is apparently unknown to them. While their facts are not too misleading, they are a few years out of date, and tables quoted from other sources are poorly labelled and incompletely cited. The symbol °/₀₀ has been changed to % without the necessary change in decimal point in several of these tables, and it would appear doubtful from the text that the authors are aware of the difference. The sentences have been carelessly put together, and as a result lost clauses and non sequiturs are common. Since the book is, in the authors' words, "a first attempt," it is to be hoped that the next edition will be more carefully edited, and that in particular the numerous citations will be completely listed in a terminal bibliography. There is a good index.

JOEL W. HEDGPETH

PENICILLIN: *Its Properties, Uses and Preparations. Council of The Pharmaceutical Society of Great Britain. The Pharmaceutical Press, London.* 10s. 6d. viii + 199 pp.; ill. 1946.

Developments in our knowledge and application of penicillin require summaries for those who find it increasingly difficult to keep abreast of its staggering volume of literature. To meet this demand the Editor of *The Pharmaceutical Journal* has collected in one small volume, for pharmacists and general practitioners, the best methods of preparing and using the drug. The book is composed of nine chapters: Historical summary; Commercial Manufacture; Chemistry and Chemical Properties; Stability; Standard, Unit and Methods of Assay; Pharmacology; Clinical Use; Pharmacy and Pharmaceutical Preparations; Legal Considerations. Primarily intended for the pharmacist, the most extensive discussion is concerned with pharmaceutical formulas. However, an excellent summary of the clinical applications and dosage is presented in 34 pages.

As is pointed out in the preface, "the majority of published papers on penicillin relate to conditions normally treated in hospitals; from the pharmaceutical angle the belief is widely held that the dispensing of penicillin calls for some entirely new technique, an erroneous view which it is hoped this book will help to dispel." Again a common misconception is pointed out: "the Pharmacopoeia has given official recognition to the pharmaceutically obvious fact that aseptic technique is only necessary in making those preparations which are to be used aseptically." It is suggested that both physicians and pharmacists must regard as obsolete much of the advice of clinical publications prior to 1946. Details of American and British standards and legislation relating to penicillin have been set forth so that the reader may make comparisons.

C. JELLEFF CARR

A HANDBOOK OF COMMONLY USED DRUGS *Including Certain Measures for the Control of Diseases Peculiar to the Tropics of the Western Hemisphere.*

By Michel Pijoan and Clark Harvey Yeager. Charles C. Thomas, Springfield, Illinois. $3.75. xii + 198 pp. 1947.

This handbook, which is the result of the author's experience in field expeditions where reference material for drug usage is difficult to obtain, describes the drug preparations, drug technics, and the treatment of common tropical diseases. The work is not designed to replace the standard text in pharmacology, but according to the authors is intended to serve as a guide when such texts are relatively unavailable.

Thirteen chapters make up the volume, in addition to a comprehensive appendix. The chapter on antibiotics appears to be particularly well organized, and a very handy table has been compiled summarizing the diseases and their response to chemotherapy, particularly as to a comparison between sulfadiazine and penicillin.

The book is not without errors, however. The chemical formulas, especially, appear to have been rather carelessly proof-read. For example, errors appear on pages 25, 55, and 86. Authors' names have been misspelled, e.g., Hartung. The section on cardiovascular drugs certainly appears to be incomplete. The newer nitrites are not mentioned and the organic nitrates have been omitted entirely from the discussion. The appendix, which contains formulas for field hospitals and a summary of the common infectious diseases, may be very useful under certain circumstances.

C. JELLEFF CARR

BIOCHIMICA ET BIOPHYSICA ACTA. *International Journal of Biochemistry and Biophysics. Volume 1, Number 1, January 1947. Bimonthly.*

Edited by W. T. Astbury (Leeds), A. Braunstein (Moscow), C. F. Cori (St. Louis), Cl. Fromageot (Lyon), K. Linderstrøm-Lang (Copenhagen), H. G. K. Westenbrink (Utrecht), and R. W. G. Wyckoff (Bethesda). Published by Elsevier Publishing Company, New York and Amsterdam, and Interscience Publishers, New York. $9.00 per year.

This new journal, excellently printed on good paper, will carry articles in English, French, or German, with summaries in both English and French. In order to insure uniformity in diagrams and figures, authors are asked to submit only pencil sketches, which will be redrawn in the editorial offices.

The first issue contains the following papers:

Investigation on the β-galactosidase of alfalfa seed emulsin, by S. Veibel and G. Østrup; Protéines de structure de Szent-Györgyi et thymonucléohistone, by J. Brachet and R. Jeener; Photochemische Spaltung des Kohlenoxydmyoglobins durch ultraviolette Strahlung (Wirksamkeit der durch die Proteinkomponente des Pigments absorbierten Quanten), by Th. Bücher and J. Kaspers; Séparations chromatographiques d'acides aminés et de peptides. I. Chromatographie de peptides neutres dans le formol à 10%, by E. Lederer and Tchen Pau Kiun; The distribution of the enzymes in resting cereals. I. The distribution of the saccharogenic amylase in wheat, rye, and barley, by Chr. Engel; Nouvelles études sur l'hydroxylysine, by P. Desnuelle and S. Antonin; Inactivation et réactivation complètes de la phosphomonoestérase alcaline et interchangeabilité des métaux actifs, by Nguyen-Van Thoai, J. Roche, and M. Roger; Die Spezifität der Mikromethoden zur Citronensäurebestimmung als Pentabromaceton, by F. L. Breusch and Rasim Tulus; Le dosage photométrique des nucléosides puriques et pyrimidiques au moyen de la réaction à l'orcine, by L. Massart and J. Hoste; On the synthesis of aneurinpyrophosphate from aneurin by blood, by H. G. K. Westenbrink and E. P. Steyn-Parvé; Sur la détermination de quantités d'azote purique de l'ordre de 10 à 40 gammas. Application aux acides nucléiques, nucléoproteides, tissus, microorganismes, by R. Vendrely.

LA RECHERCHE CHIMIQUE EN FRANCE DE 1940 À 1945. *Conférences faites au Congrès de la Victoire de l'Association Française pour l'Avancement des Sciences. Bulletin de la Société Chimique de France. Suppl. 1946.*

By G. Champetier, J.-V. Harispe, and L. Velluz. Introduction by R. Delaby. Bureaux de la Société Chimique de France; Masson et Cie., Paris. Paper. 46 pp.

This supplement reviews chemical research in France during the war years in three articles, dealing with: (1) physical chemistry and mineral chemistry (Champetier); (2) organic chemistry (Harispe); (3) biochemistry (Velluz). Publications such as this are of worldwide service in reacquainting scientists with the scientific progress made in other lands in those days of disrupted communications, and in restoring the international character of scientific work.

MICROBIOLOGY

L'ORGANISME EN LUTTE CONTRE LES MICROBES. *L'Avenir de la Science—24.*

By André Boivin and Albert Delaunay. Librairie Gallimard, Paris. 320 fr. (paper). 425 pp. + 14 plates. 1947.

This book contains an extremely advanced and detailed presentation of the various factors involved in infections by bacteria and viruses and the defenses of the body, lifting it well above the popular or elementary level. Unfortunately, references are almost completely lacking, although the names of various workers (without dates) are given occasionally in the text. The very brief bibliography merely lists a few books and gives the names of several well-known journals. For those who wish an advanced description of the factors involved in infection, immunity, and resistance, taking the authors' statements on faith, the book may be of interest. For those who wish to refer (at least occasionally) to primary sources, the book is likely to be more of an annoyance than a help.

WALTER C. TOBIE

AEROBIC MESOPHILIC SPOREFORMING BACTERIA. *Miscellaneous Publication Number 559.*

By Nathan R. Smith, Ruth E. Gordon, and Francis E. Clark. United States Department of Agriculture, Washington, D. C. 25 cents (paper). 112 pp. + 1 plate. 1946.

This excellent publication presents an enormous amount of careful taxonomic work on the genus *Bacillus* (as defined by the Bergey system), using 363 named strains, and 258 received without names, or isolated by the writers. On the basis of their morphology and physiology, the bacilli are classified into three large groups: Group 1, sporangia not definitely swollen; Group 2, sporangia definitely swollen by oval spores; and Group 3, sporangia swollen by round spores. A key is given. The percentages of the cultures falling in each group were 77, 19, and 4 per cent respectively, but this may not represent their relative abundance in nature. A modified Voges-Proskauer reaction was important and reliable in separating some species. Tests for the storage of fat and the fermentation of carbon compounds were also valuable in differentiation, while bacteriophagy was useful in some cases. Agglutination by antiserums (with whole cells as antigens) was unsuitable for taxonomic use. There is a useful index which compares the names of the cultures, as received, with the final identification by the authors. No new species or varieties are described, but some new combinations are given. One of the most interesting is the reclassification of *Bacillus anthracis* as *Bacillus cereus* var. *anthracis*. The work is of considerable practical as well as theoretical importance, owing to the isolation of

various antibiotics from organisms of this genus, as well as the use of some species in other technical applications. The publication should be a very useful supplement to the sixth edition of Bergey's *Manual of Determinative Bacteriology*. There are 119 references.

WALTER C. TOBIE

WATER BACTERIOLOGY *With Special Reference to Sanitary Water Analysis. Sixth Edition.*

By Samuel Cate Prescott, Charles-Edward A. Winslow, and Mac Hervey McCrady. John Wiley & Sons, New York; Chapman & Hall, London. $4.50. xiv + 368 pp. 1946.

This well-known work has been almost completely rewritten since the fifth edition appeared in 1931; with the collaboration of a new author, M. H. McCrady. Little attention is paid to bacteria indigenous to natural waters. The main stress is upon organisms introduced by human and animal agencies, which may be regarded as of significance to public health and sanitation. Accordingly, four of the thirteen chapters deal primarily with coliform bacteria, with one chapter on other bacteria that have been used as indices of pollution. Although the results obtained by various methods of examination are discussed in detail, the book is not in any sense a laboratory manual. Instead, it is intended to provide a historical and philosophical background for various methods of bacteriological examination of water, with particular stress on the current standard methods of the American Public Health Association. From this point of view, it should be of great value to laboratory workers engaged in the bacteriological examination of water, as well as being a useful textbook for those studying the subject for the first time.

Although the subject matter is brought fully up to date, abundant attention is paid to earlier work, which in many cases is still of great importance. One of the most valuable features is an excellent bibliography of 53 pages. Another commendable feature is that statements made in the text are supported by references to the workers who originally made the observations.

WALTER C. TOBIE

INTIMATE BACTERIOLOGY: *A Text and Laboratory Manual. Revised Edition.*

By Casper I. Nelson. Burgess Publishing Company, Minneapolis. $3.00 (paper). viii + 216 pp.; ill. 1946.

This manual, bearing a rather unusual title, has been reproduced from typed sheets by the mimeoprint process, with photo offset for some of the figures. The reproduction is remarkably clear and satisfactory.

The first portion comprises lectures (given at the North Dakota Agricultural College) in a second course of general bacteriology which follows an elementary course. Stress is laid upon the hygienic bacteriology of daily life, from the prenatal period to old age, for those who do not necessarily wish to follow the subject into medical bacteriology. The second portion of the manual consists of twenty-eight laboratory exercises, with blank pages opposite upon which the student's laboratory notes may be entered.

Students should find the text extremely interesting and readable. Unfortunately, there is a rather general looseness of statement and of interpretation which mars its value appreciably. The references (given as footnotes) follow no consistent style, and are frequently incomplete. Nevertheless, the manual is of interest in pointing the way for others to produce similar works. Such measures are particularly recommended for those who consider that none of the available textbooks and laboratory manuals are really satisfactory for teaching bacteriology as they would like to teach it.

WALTER C. TOBIE

HEALTH AND DISEASE

NEW WORLDS IN MEDICINE. *An Anthology.*

Edited with commentary and introduction by Harold Ward. Robert M. McBride and Company, New York. $5.00. 707 pp. 1946.

This is an anthology of 34 selections dealing with the development of medicine in the twentieth century, skilfully selected and abridged by the editor. The panorama provided is exceptionally complete: Highlights of 20th Century Medicine (Logan Clendening); War and Medicine (Edgar Erskine Hume); Medicine in World War II (George W. Gray); Aviation Medicine (Henry T. Ricketts); American Surgeons at War (Fred W. Rankin); Blood, the Elixir of Life (Justina Hill); The Pathologist: Doctor Anonymous (Wm. McKee German); The Doctor and the Physicist (Geo. Russell Harrison); The Dream of Paul Ehrlich (Iago Galdston); Chemical Warfare Against Disease (Perrin H. Long); The Virus, Life's Enemy (Kenneth M. Smith); Influenza, the Killer (Geo. W. Gray); Meet the Bacteria (Wm. H. Park and Anna W. Williams); The Conquest of Epidemics (C.-E. A. Winslow); Immunity Against Disease (Hans Zinsser); Domesticating the Microbe (René J. Dubos); The Glands—Servants or Masters? (Oscar Riddle); Cancer, Enigma of Medicine (Charles Oberling); Growth and Decay (Ralph W. Gerard); On Growing Old (Bentley Glass); Creative Old Age (Martin Gumpert); A Doctor Looks at Old Age (Llewellys F. Barker); Anaesthesia and Antiseptics (C. D. Haagensen and W. E. B. Lloyd); William Beaumont's Rendezvous (Harvey Cushing); The Reaction to Food (Elmer V. McCollum); The Use and Abuse of Diet (A. J. Carlson); Alcohol and Behavior (H. W. Haggard and E. W.

Jellinek); The Inheritance of Mental Disease (Abraham Myerson); Borderland of Psychiatry (Stanley Cobb); Towards Mental Hygiene (Albert Deutsch); Training Young Doctors (H. B. Clapesattle); Preventive Medicine (David Riesman); Medicine and Society (Bernhard J. Stern); Public Health in the Soviet Union (Henry E. Sigerist). Not all of these contributions were written even within the last ten years, so that the reader ought not to expect this to be an up-to-the-minute resumé of of modern medicine. It is, as was said before, a broad and varied panorama of medicine, together with its biological backgrounds and social relationships, written by some of America's outstanding scientific writers.

AN APPROACH TO SOCIAL MEDICINE.

By John D. Kershaw. A William Wood Book, The Williams & Wilkins Company, Baltimore. $4.50. x + 329 pp. 1946.

To this author, health is the goal of life. "Because of the fundamental importance of health in society, it is necessary that all human action and activities, whether undertaken by an individual or by a group, should be considered in relation to health, and that the value of an action or activity should be judged in the light of the effect which it will have, or will be likely to have, upon the health and well being of the individual, group, or society as a whole." This implies that the doctor is called on to be the leader of society. "It lays upon medicine an implied duty to lead social development towards a state of society which will directly foster positive health." It is only consistent with these premises that the medical man should therefore be concerned with the inequalities and disparities of society, with education, the "hormone" of society which promotes reason, and with economics. This philosophy may sound queer at first. Actually, the author only formulates clearly the logical conclusions of what a great many people believe in practice. Health, originally only a byproduct of religious practices, has become, indeed, for many the only religious value. If this is true, then our society is indeed becoming a "medical society." To be sure, this idea is not really new. It was fairly current in France and Germany about a hundred years ago.

The author is again consistent with his premises when in the first part of his book he deals with the anatomy of society (family, local community, state, occupational group); the physiology of society, that is, the relation of the individual to society, and the form of government; and the pathology of society, that is mainly crises of government and economy. This is not the place to go into a discussion of the good and the weak points of this general exposition, which as a whole follows the ideas of the British Labor Party.

The strongest part of Kershaw's book is probably the second, which deals with medicine in society, and in which he discusses fields wherein the social connections of medicine are very obvious, such as industrial medicine or public health, as well as those in which the social connections of medicine are less obvious, but nevertheless, very influential, such as surgery or gynecology. In a third part of the book, the author outlines the fields on which social medicine has to concentrate its efforts in order to foster positive health: that is, food, housing, working conditions, leisure, genetics, sex, handicapped people, and education.

One's final judgment on this book will, of course, depend upon the attitude of the reader toward the fundamental philosophy of the author. The reviewer can neither agree with the opinion that health is an ultimate value, nor that doctors are called on to lead society. It is, on the other hand, extremely important that doctors should see the social implications of their activity, and act accordingly. After trying for almost twenty years to bring out the social implications of medical practice, I feel, therefore, that perusal, particularly of Parts Two and Three will be extremely valuable to every medical man, whether he subscribes to the author's fundamental philosophy or not. The book is thoroughly sympathetic in its modesty and clarity.

ERWIN H. ACKERKNECHT

HYGIENE: *A Textbook for College Students on Physical and Mental Health from Personal and Public Aspects. Fourth Edition.*

By Florence L. Meredith. The Blakiston Company, Philadelphia and Toronto. $4.00. xii + 838 pp.; text ill. 1946.

This textbook (third edition reviewed, Q. R. B. 16: 372. 1941) has been completely reset and rearranged in order to bring it up to date and to incorporate the advances in medicine and public health made in the course of World War II. The introductory chapter, on The Health Situation in the United States, shows this revision in particular. Revised vital statistics and Army figures for the causes of rejection of draftees have been used. In general, the plan and purpose of the book remain as in the earlier editions, and the remarks about the third edition still apply in full measure. This is a good, comprehensive college textbook that will be of limited service outside of hygiene and public health courses.

A few minor shortcomings may be mentioned. Information about the hereditary bases of defects and diseases is not fully utilized, particularly that from the twin studies which have thrown so much light on tuberculosis, epilepsy, and various psychoses. The great present significance of the sulfonamides, penicillin, and streptomycin seems little apparent from the scattered character of the references to their effects. Misleading

statements such as the following are occasionally met: "It is the first exposure to a substance that is responsible for sensitizing a person to that substance" (by no means always the case); or, regarding Rh sensitization, "subsequent pregnancies may be made safe by methods now known to science. . . ." There is not infrequently a tendency, as in the latter case, to gloss over a situation and make it seem better than it really is. In regard to the sex impulse, there has been little effort to bring the information and point of view up to date; although this does not mean that the attitude maintained is altogether out of line with present knowledge. The figures are in many instances old and unattractive and should be replaced. In spite of these minor flaws, the textbook is certainly to be classed among the best in its subject.

BENTLEY GLASS

AWAKE AND AWAY.

By Leslie W. Irwin, Waid W. Tuttle, and Caroline De Kalver. Illustrated by Martha E. Miller and Miriam S. Hurford. Lyons and Carnahan, Chicago, Dallas, Los Angeles, Atlanta, and New York. 66 cents. ii + 62 pp.; ill. 1947.

This book is one of three that form a graded series, designed for instruction in health and safety at beginning school levels. The illustrations, done in the gaudy, full-blown colors so nauseatingly familiar in children's books, serve as the working background for the supplementary explanations which must come from the teacher. They incorporate no marked improvements over the many similar texts which have preceded them.

C. P. SWANSON

THE GIRL NEXT DOOR. *Health and Personal Development Series.*

By Dorothy Baruch and Elizabeth Montgomery in consultation with W. W. Bauer. Illustrated by Ruth Steed. Scott, Foresman and Company, Chicago, Atlanta, Dallas, and New York. $1.20. 256 pp.; ill. 1946.

This textbook of elementary hygiene for fourth grade children (10-year-olds) is characteristic of a current trend in the preparation of school books for the lower grades. It is written almost completely in story form, with scattered sections of straight exposition and summary of principles. At the end of the book, for the teacher, there is a vocabulary list, followed by notes on the facts and principles presented in the text, section by section, and an index to them. The illustrations are attractive and the stories well written. Undoubtedly the book will interest children, and in the hands of a good teacher ought to prove an extremely successful device to stimulate learning and to inculcate desirable attitudes. It is just at this level that the story-book form of textbook seems most effective.

BENTLEY GLASS

GOOD HEALTH IS FUN. *Health-Happiness-Success Series [4th Grade].*

By W. E. Burkard, R. L. Chambers, and F. W. Maroney. Lyons and Carnahan, Chicago, Dallas, Los Angeles, Atlanta, and New York. 75 cents. viii + 295 pp.; ill. 1946.

YOUR HEALTH AND HAPPINESS. *Health-Happiness-Success Series [5th Grade].*

By W. E. Burkard, R. L. Chambers, and F. W. Maroney. Lyons and Carnahan, Chicago, Dallas, Los Angeles, Atlanta, and New York. 75 cents. viii + 307 pp.; ill. 1946.

BUILDERS FOR GOOD HEALTH. *Health-Happiness-Success Series [6th Grade].*

By W. E. Burkard, R. L. Chambers, and F. W. Maroney. Lyons and Carnahan, Chicago, Dallas, Los Angeles, Atlanta, and New York. 75 cents. viii + 318 pp.; ill. 1946.

HEALTH FOR YOUNG AMERICANS. *Health-Happiness-Success Series [7th Grade].*

By William E. Burkard, Raymond L. Chambers, and Frederick W. Maroney. Lyons and Carnahan, Chicago, Dallas, Los Angeles, Atlanta, and New York. 75 cents. viii + 375 pp.; ill. 1946.

WORKING TOGETHER FOR HEALTH. *Health-Happiness-Success Series [8th Grade].*

By William E. Burkard, Raymond L. Chambers, and Frederick W. Maroney. Lyons and Carnahan, Chicago, Dallas, Los Angeles, Atlanta, and New York. 75 cents. viii + 373 pp.; ill. 1946.

A graded series of books scaled to the intellectual levels of the readers, these volumes present in realistic fashion the problems of personal, physical, and mental hygiene and community well-being. The illustrations are good and the text readable and instructive.

SYNOPSIS OF PATHOLOGY.

By W. A. D. Anderson. The C. V. Mosby Company, St. Louis. $6.50. 741 pp. + 15 plates. 1946.

In the preface to the second edition of this work, W. A. D. Anderson states that his objective is to give a "concise but comprehensive presentation of pathology." He has been remarkably successful in his aim and has included in this volume virtually all pertinent phases of pathology. At the same time the descriptions of pathological lesions are full and interesting; and diver-

gent theories of etiology are always given so as to prevent the text from becoming dogmatic. In spite of its brevity this second edition is fuller than the first, and there are chapters on many pathological conditions omitted from recent voluminous and therefore supposedly more complete textbooks of pathology.

The sequence of chapters is good. A survey of general principles and specific infections is presented first, and is followed by a review of the systems. The bibliography is excellent, stressing recent reviews and recent advances in knowledge rather than the historical literature. Numerous excellent illustrations add to the value of the text.

In summary, this volume should prove useful to the medical student as an adjunct to his other texts and reference books; and to clinicians and biologists in general who need a concise modern reference book of pathology.

ELLA H. OPPENHEIMER

PATHOLOGY. *Fifth Edition.*

By Eugene C. Piette. F. A. Davis Company, Philadelphia. $2.00. 261 pp. 1945.

This volume is a textbook of pathology for nurses. Because the survey of prerequisite necessary information has been superficial, the rudiments of pathology, too, have had to be presented in over-simplified and therefore superficial fashion. Yet Piette has managed to cover a wide field and to present a great variety of pathological facts, stressing those of most practical importance to the nursing profession. A few facts are somewhat distorted by the over-simplification, but on the whole, the author gives a good condensation of pathological principles. For this reason, this volume may be of interest not only to nurses, but also to other individuals who desire a brief, if not thorough, survey of pathology.

There are numerous illustrations. Though well chosen, the photographs are technically very poor and should certainly be improved for the next edition of this text.

ELLA H. OPPENHEIMER

PRINCIPLES OF HEMATOLOGY. *Third Edition.*

By Russell L. Haden. Lea & Febiger, Philadelphia. $5.00. 366 pp.; ill. 1946.

This volume presents a brief, elementary survey of the field of hematology in a somewhat discursive style. It is abundantly illustrated, but most of the illustrations, although technically good, are in black and white and insufficiently magnified to be of any great help to the novice, for whom the book is intended. The merit of a simple introduction to a complex field such as this cannot be denied, but this type of presentation would be distinctly more valuable with the addition of a carefully selected bibliography designed to assist the interested reader. The bibliography is scanty and no references beyond 1939 have been included. Many important recent developments, such as the introduction and use of folic acid in the macrocytic anemias, or of nitrogen mustards in the leukemias and lymphomata, to mention but two, are not discussed at all.

MILTON S. SACKS

DISORDERS OF THE BLOOD: *Diagnosis, Pathology, Treatment and Technique. Fifth Edition.*

By Sir Lionel E. H. Whitby and C. J. C. Britton. The Blakiston Company, Philadelphia. $10.00. xii + 15 plates; text ill. 1946.

Previous editions of this text have established a firm position for the book in the literature of hematology. This, the fifth edition, continues to maintain this position. The volume has been increased in size by 62 pages, and extensive revisions have been made in the chapters dealing with the origin and development of the blood cells, the hemolytic anemias, the anemia of infancy and childhood, hemagglutination, blood transfusion, and technique. A brief but comprehensive consideration of the Rhesus factors has been included. The bibliography is extensive and well selected. The illustrations are adequate. The book can be recommended to all interested in the field of hematology.

MILTON S. SACKS

PRACTICAL MALARIOLOGY. *Prepared Under the Auspices of the Division of Medical Sciences of the National Research Council.*

By Paul F. Russell, Luther S. West, and Reginald D. Manwell; foreword by Raymond B. Fosdick. W. B. Saunders Company, Philadelphia and London. $8.00. xx + 684 pp.; ill. 1946.

This manual belongs to the now famous series of military medical manuals issued by the National Research Council during the late global conflagration. The book is dedicated to the personnel of the special field malaria control organizations of the armed forces of the United States in World War II, an organization of which both authors and reviewer were members. As it was not really finished until the post-war period, it has been written, the authors point out, primarily from the standpoint of civilian needs rather than as a military book. While making use of the many lessons learned on the battlefield, the authors stress the application of tried and true principles to similar problems arising now and in the future in public health practice. Without reservation, this is the best publication of its kind

to date. It should serve as a basic source book for every malariologist undertaking control of malaria in the field, and as well it represents a valuable textbook for students and practitioners.

The manual is divided into six logical sections: the parasite; the mosquito; the man; the community; prophylaxis and control; and therapeutic malaria. These sections are prefaced by a thorough historical introduction, and followed by an appendix that contains a series of keys to the adult and larval mosquitoes of different parts of the world. There is also a table of equivalents of measure which should be very useful in the field. There is a twenty-two page subject index.

No greater compliment can be paid to the writer of a historical introduction than to say that he has made it genuinely interesting as well as satisfactorily inclusive. This can be truthfully said about this section of the book.

The title *Practical Malariology* is not to be construed as an indication that this volume is strictly a laboratory manual and that it contains absolutely no theoretical material. The first three chapters of the section on the parasite deal extensively with academic considerations of the variety of animal hosts possible, with the life cycles of the plasmodia, and with the morphology and physiology of human and animal plasmodia. The phases of the life cycle, both in man and mosquito, are clearly discussed, and disputed points, such as the exo-erythrocytic stage and the origin of gametocytes, are elucidated. The morphology of the four human-parasite species is illustrated by excellent original colored diagrams of thin and thick blood films prepared by U. S. Army technicians and artists. Also included are colored plates from the well known bulletin on malarial diagnosis by Aimee Wilcox of the U. S. Public Health Service. The drawings are supported by a clear description of the development of the erythrocytic stages of the parasite and helpful suggestions on laboratory diagnosis. The chapter on the animal-parasite plasmodia, obviously a contribution of Manwell, brings out the important role which avian and simian malaria have played in understanding the pathogenesis and treatment of malaria. Also briefly reviewed is the literature which deals with the plasmodia of such mammals as the bat, squirrel, buffalo, and antelope, as well as those parasitizing reptiles or amphibians.

The chapter on laboratory technique does not give as much detailed discussion regarding the use of the different stains and the sources of difficulty as may be necessary for the beginner. Virtually all of the well-known and some very new techniques have been included. The section on the preparation of stains and solutions is very good.

Section II, which deals with the mosquito, consists of five chapters devoted to taxonomy, bionomics, the distribution of different species, and to field and laboratory techniques. Into these chapters have gone the systematic knowledge and field "know-how" distilled from long hours of sweat and blood spent by both military and civilian malariologists. Upon the techniques described herein is based the true worth of any competent mosquito survey. The authors have omitted mention of no technique which has proven to be an aid toward an accurate survey of mosquito populations within any given area.

The pathology, clinical aspects, treatment, and immunity of malaria as affecting man are presented in the four chapters of Section III. This is a digest of the latest research work, and is clearly and concisely worded. The chapter on treatment is well supported by pharmacological data in the form of references to the well-known work of Field, James, Brodie, and Shannon, and other modern contributors to this general subject. Immunity, latency, and relapse are discussed succinctly. A discussion of black-water fever, the time-honored mystery of malariology, completes the section on man.

The knowledge of how malaria comes to be a community problem, i.e. the epidemiology of the disease, is considered in its various aspects in Section IV. The authors here discuss the distribution and prevalence of malaria, the part human groups play in its spread, the part mosquitoes play in its effect upon communities, and various climatological factors. A considerable amount of space has been given to a description of how epidemics develop and how they may be prevented. For the public health officer who is new at his work, a most complete plan of a community survey has been provided, giving methods of estimating the density of infection, the duration of the disease in a community, and the methods of analysing data.

One of the main purposes of this manual is to present the principles of field and laboratory malaria control. Section V, consisting of almost two hundred pages, divided into nine chapters, is devoted to prophylaxis and control. First, the problem of malaria control is logically outlined and then considered step by step. There is a brief chapter on control of the parasite, a chapter which covers prophylactic treatment, artificial immunization, and related subjects. The greater part of this large section is taken up by a detailed discussion of control of the mosquito, both in its larval and adult stages. Also included are many diagrams and pictures of field operations, figures which will prove helpful to public health officers directing the field engineering of malaria control projects. There is a careful evaluation of the various insecticides, both as larvicidal and adult killing agents. The section on DDT is adequate, though in view of the voluminous and interesting literature now available, it might have been more extensive. Little is said about dispensing insecticides in form of volatile mists from steam generators, a method which was tried with reported success in some of the war theatres. Control of man-made malaria through eradicating mosquito breeding in man-made situations, edution programs, and the segregation of infected

individuals, are duly stressed. The part the community must take and its legal and medical obligations in public health programs are important points mentioned under community control. A chapter on malaria control under military conditions, and a brief review of the experimental work which has been done in therapeutic malaria complete the manual. The appendix, containing the taxonomic keys, has already been mentioned.

One very excellent feature about this manual is the thoroughness with which the authors have listed their references. This will increase the usefulness of the work to those who wish to go to the original literature. The book is printed in clear, bold type of attractive style. The paper is of very high quality, and the binding is durable and attractive.

ALAN C. PIPKIN

MANSON'S TROPICAL DISEASES: *A Manual of the Diseases of Warm Climates. Twelfth Edition.*

Edited by Philip H. Manson-Bahr. A William Wood Book, The Williams & Wilkins Company, Baltimore. $12.00. xiv + 1068 pp. + 26 plates + 6 maps + 2 charts; text ill. 1945.

The last five editions of this manual, which have appeared during the last twenty years, have been edited by the son-in-law of the original author. The last two editions, the eleventh, which appeared in 1940, and the present one, reflect the progress made in this field during the early years of the most recent global war. These editions also show a conscientious attempt on the part of the editor to weed out what has been learned to be erroneous and to state the material as concisely as possible.

The eleven major sections are subdivided into forty-nine chapters, to which there is added an appendix of about two hundred pages and an adequate subject index. Many chapters have been completely rewritten since the last edition, not always with any addition of new material, and often with the elimination of unnecessary passages. The consideration of certain subjects has been slightly expanded and reset in smaller, though still easily legible, type, so that the total number of pages is considerably shorter than that of the previous edition.

The first third of the book, consisting of twenty-three chapters, is taken up by a consideration of febrile diseases caused by six general types of etiologic agents. The chapter on malaria, except for a general rewording, shows few changes from the eleventh edition. Although in most cases the editor has shown admirable judgment in selection, there are some points which might have profited by fuller discussion. For instance, while Manson-Bahr barely mentions the very important exoerythrocytic phase in the malarial life cycle, he has spent a whole page discussing such bizarre aspects of the epidemiology as infection by blood transfusion and the possibility of infection of a foetus from its mother. The portion dealing with the prophylaxis of malaria is obviously meant to be brief. Yet it seems that since DDT has been universally accepted as the most useful available insecticide for this purpose, more space might have been devoted to a discussion of its use and less to pyrethrum and repellents.

The chapter on trypanosomiasis brings out the intimate connection which the English have had with the development of our knowledge of this blood parasite and its clinical effects. There is an excellent map of equatorial Africa that shows the distribution of African sleeping sickness. The consideration of South American trypanosomiasis is brief but gives the salient facts. Visceral, cutaneous, and muco-cutaneous leishmaniasis are admirably discussed. The reviewer has recently observed several cases of the infantile type of kala-azar from Northern Syria and has seen hospital case reports of some 25 cases in children and adults, reported over the last twenty years, from Syria and Lebanon, areas of endemicity which the editor has failed to include in his description of the geographical distribution of this disease, although he does mention nearby Palestine.

Three chapters are devoted to the spirochaetal fevers, including relapsing fevers, leptospirosis, and rat-bite fever. Two chapters deal with fevers produced by rickettsia and bartonella bodies. The various fevers of the "typhus group" are discussed at some length, including the comparatively atypical "Q" fever, trench fever, and the more recently described Bullis fever of Texas. The latter is very likely more closely related to Japanese river fever than to epidemic typhus or related fevers.

Fevers caused by bacteria, including plague, tularemia, brucellosis, melioidosis, and enteric bacterial diseases, make up a subsection of five chapters. The chapter on plague includes interesting material on rodent hosts and insect vectors as well as methods of eradicating both. The chapter on enteric fevers seems a bit brief.

The subsection on diseases caused by viruses includes chapters devoted to yellow fever, Rift valley fever, psittacosis, rabies, dengue, phlebotomus fever, the several pock diseases, and finally a chapter on heat stroke, heat exhaustion, and sunstroke as the cause of febrile syndromes. This completes the first large section of the book.

The next ten sections are made up of groups of chapters upon various large classes of tropical diseases. There are sections on avitaminosis, abdominal diseases, infective granulomatous diseases, diseases of the central nervous system, peculiarly local diseases, diseases due to animal parasites, and diseases due to poisons produced by snakes, flies, and leeches. Finally, there is a section on techniques that includes a chapter on blood transfusions and another on the drugs used in the treatment of tropical diseases. There is some

overlapping in the chapter on the dysenteries, the etiology of which is already partially considered under the discussion of the enteric fevers. There are other examples of such repetition, which always arises when diseases are discussed under several classifications, a practice that usually adds nothing to the effectiveness of presentation and often makes for an unduly voluminous book.

The third and last major division of the book consists of a two-hundred-page appendix on medical zoology and laboratory methods. Through some oversight, the subdivisions of medical helminthology and medical entomology are classified in the table of contents and in the subject heading at the beginning of the text section as subdivisions under medical protozoology, an error which can only be blamed on the typesetter and proof reader.

Criticism of the text material of a book edited and re-edited as many times as this one, soon dissipates, as the previous comments indicate, into personal opinions as to what is deserving of inclusion or omission. If such a widely accepted text as this has any single obvious defect, it is that of including too much within its scope. The present volume might have been improved by an editorial decision to limit the scope to matters strictly concerned with tropical medicine. For example, the chapter on blood transfusions might well have been omitted. Then it seems questionable, too, to devote a whole chapter to a tabular list of the formulae of chemotherapeutic agents without giving the complete pharmacological information needed to evaluate the efficacy of the different compounds. The sections on medical zoology in the appendix also repeat, in part, material already given in the body of the text. While it is admittedly very important for clinicians to have an accurate appreciation of the details of the life cycles of various parasites, these might better have been included in the text and integrated with the discussion of the clinical effects produced.

The book as a whole is attractively printed and composed. It is profusely illustrated with charts, maps, line drawings, and photographs, most of which have appeared in previous editions. The colored plates of malarial parasites, only slightly changed in this edition, are beginning to lose their definition, due no doubt to some difficulty in printing. The plates picturing the intestinal protozoa leave much to be desired as to accuracy and clarity. The quality of the paper upon which the book is printed is good, and the volume is attractively bound.

ALAN C. PIPKIN

PSYCHOLOGY AND ANIMAL BEHAVIOR

THE PERSONALITY OF ANIMALS. *Pelican Books. First American Pelican Books Edition (Revised).* *By H. Munro Fox. Penguin Books, New York.* 25 cents (paper). 116 pp.; ill. 1947.

As the title implies, the text is a popular account of various aspects of animal behavior. These include discussions of such phenomena as animal play, migration, the things that animals can see and hear, and how animals communicate with each other. In addition, the problem of distinguishing instinct from intelligence is considered, and other topics of popular interest are treated in a readable and stimulating fashion. The illustrations, however, are poor, both in selection and reproduction.

JOHN E. CUSHING

WHAT IS PSYCHOLOGY: *A Basic Survey.* *By Werner Wolff. Grune & Stratton, New York.* $4.00. xiv + 410 pp. 1947.

In the preface to this book, Wolff states that he has asked students of psychology why they chose to pursue that particular course. The largest group wanted help in their professions. Another group wanted to understand and help people. The smallest group wanted to understand themselves. The author, on the other hand, states that he himself expects nothing from psychology but a questioning attitude. This book, then, has been written—according to the author—to satisfy himself and those few students who happen to agree with him in what they expect from psychology.

Laying aside the question of whether such an aim is ever justified in writing a textbook for elementary courses, there is still the question of whether the author has accomplished his goal of stimulating the student's psychological thinking. It is the reviewer's opinion that he has not. The book is written with a very heavy Gestalt and personalistic bias, and other points of view are hardly mentioned, outside of the usual conciliation in the introductory chapter. This bias has resulted in an almost complete exclusion of material not amenable to Wolff's treatment. Treatment of the material so strongly in terms of one theoretical bias certainly is not calculated to raise questions about the nature of psychology in the student's mind, but rather leaves behind a false sense of security and exactitude about what we know. If the author had really wanted to raise questions, he should have included controversial material and alternative theories.

Sensation is covered in seven pages. There is no section on action. Not a single reference to C. L. Hull appears in the sections on learning. Such treatment cannot give the student a fair appraisal of the subject matter of psychology. If questions are indeed raised in the student's mind, it is quite possible that they could be answered if the material covered was not so limited by the bias of the author.

When a textbook in psychology is written in this manner, one wonders whether psychology has ever emerged from the department of philosophy in the minds of the writers. Certainly present-day psychology is more of a science than this gives the appearance of being. Certainly we know more than is indicated here. Certainly there must be some other place where what is known is presented in a more objective fashion for the majority of students who wish to learn, and not merely to ask themselves questions throughout the year.

W. R. GARNER

THE APPLICATION OF THE RORSCHACH TEST TO YOUNG CHILDREN. *The Institute of Child Welfare, University of Minnesota, Monograph Series No. XXIII.*

By Mary Ford. The University of Minnesota Press, Minneapolis. $2.00. xii + 114 pp. 1946.

This is a careful exploratory study done to evaluate the use of the Rorschach test as it is now applied to very young children. It is a most provocative subject and one which the author, an associate professor of child development and family relationships at Cornell University, has dealt with in a scholarly but never pedantic fashion. As she herself states, this monograph "raises more questions than it attempts to answer" and points the way concretely to a great deal of future work.

Ford gave the Rorschach test to 123 children ranging in age from 3 to 8 years. In this process she developed certain administrative refinements of significance in presenting Rorschach material to young subjects successfully. Working up the test results, she shows how some of the test determinants vary with the chronological age and mental age of the subject, but that, at least in her group, there were no determinants which varied according to the sex of the subject. She also reports that some of the test determinants are reliable when applied to young children, whereas others need to be reconsidered for this special sort of group. She aptly stresses the need for standardizing this test for more intelligent and valuable usage with the pre-school child. In addition to making these original observations, Mary Ford has compared her results minutely with the conclusions reached in the few previous studies of a similar nature.

Of especial importance to clinical workers with children are not so much the formal conclusions which Mary Ford draws so ably as rather the implications of the insight to be gained into child thinking through the use of a properly standardized projective test. It is to be hoped that serious Rorschach students will take up some or all of the author's twelve suggestions for future research in this area.

HELEN HEWITT ARTHUR

FATHER OF THE MAN: *How Your Child Gets His Personality.*

By W. Allison Davis and Robert J. Havighurst, with a chapter by Helen Ross. Houghton Mifflin Company, Boston. $2.75. x + 245 pp. 1947.

This book, written primarily for parents and laymen, has as its basic purpose a careful exploration of the consequences of middle-class culture upon children. By a skilful integration of the anthropological, psychological, and psychoanalytic points of view, the authors present their material clearly and convincingly. They are carefully non-evaluative in their language, but there is little doubt that the import of the book is that middle class parents are unnecessarily rigid and impose too great a burden of learning and self-restraint upon the child.

Being a book intended to be read by parents, this volume contains a short section of advice at the ends of several chapters; but the general advice conveyed throughout the book is to love children more, give them more freedom, and be in no hurry about training them. And for middle-class parents no advice could be better. There is another group of parents, however, the so-called intellectuals, who will probably constitute a fair share of the authors' audience. For them the book may lose much of its impact because they already condemn such specific middle-class patterns as rigid feeding schedules and early toilet training. For this group, the inclusion of those subtler prohibitions and pressures characteristic of the intellectual culture would have been fortunate. Still another kind of parent who will eagerly devour this and similar books on child care also deserves some attention. This parent, already too aware of the importance of warmth, tolerance, and relaxation, is emotionally unable to be warm or tolerant or relaxed. For such parents, and others too, what is needed is not so much a generalized description of middle-class culture as an analysis of how, within that culture, various parents with various needs may produce well-adjusted children.

Like most popular presentations, the book does not contain all the qualifications and cautions which a scientist likes to see. Elaborate qualification is no asset, however, for popular writing, and the authors are to be congratulated on their ability to be definite without continually arousing antagonism in the mind of the psychologically trained reader.

ALFRED L. BALDWIN

HOME GUIDANCE FOR YOUNG CHILDREN. *A Parents' Handbook. Revised Edition.*

By Grace Langdon (Ackerman). The John Day Company, New York. $4.00; $3.20 (educational edition). xiv + 357 pp. + 8 plates. 1946.

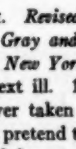
This is a complete revision of the popular book (1931) which won an award from *Parents' Magazine*. The book appears to be all that its title proposes. As such, it falls in the "cook-book" class and should find a welcome spot alongside *Fanny Farmer's Cook Book* and the Almanac. It doesn't pretend to be a scientific treatise on child psychology. Yet there is little in it contrary to scientific evidence.

The style is chatty, "homey," and readable, though far from exciting or fascinating. It has the flavor of personal experience and common sense. Its author obviously likes children and takes their side against the dominating, strict, or casual parent. It is full of grandmotherly advice, most of which is eminently practical and probably sound.

Books like this should be judged by parents rather than by professors. Inasmuch as there are very few general rules one can publish for parents, the success of any advice depends very largely on the ability of the advisor to anticipate the more common problems of family life. Thus a parent, by reading, can prepare his answer to the child's query—"What is God?" or "Where did I come from?"—well in advance, provided, of course, he hasn't already done so long ago, or provided he feels the need of advice on such matters. Even so, he cannot hope to find answers to *all* the queries of his offspring, either in this or any other book.

Of course, the advice given is "culture bound." It doesn't tell how to rear Polynesian children. But it does seem to be remarkably free of class bias, though its prescriptions are mainly for the middle class child of today. Very likely the parents who need to read it, won't, and vice versa. Still, there are some educated parents who are strangely obtuse about everyday matters. This book may help them.

S. B. WILLIAMS



THE BASES OF SPEECH. *Revised Edition.*
By Giles Wilkeson Gray and Claude Merton Wise. Harper & Brothers, New York and London. $3.50. xviii + 610 pp.; text ill. 1946.

The reviewer has never taken a course in "speech" and therefore does not pretend to say what a first-year speech student should know. This book, however, is obviously designed as a fundamental textbook and not merely as a guide to effective public speaking. It contains nine chapters, each of which is entitled, "The ..... Basis of Speech." For ....., substitute in order Social, Physical, Physiological, Phonetic, Neurological, Psychological, Genetic, Linguistic, and Semantic. Each chapter is a scholarly, though somewhat pedantic, textbook in itself. In fact, there is relatively little integration of the chapters. For example, the chapter on the physics of speech is simply a short treatise on the physics of sound. Likewise the chapter on the neurological basis of speech is little more than a short course in neurology. This tends to give the book the character of an assembly job, as if the authors had simply gathered a pile of texts from nine fields and made a kind of "reader's digest" of each of them. In view of the fact that this is precisely the way many good textbooks *are* written, one perhaps ought not to criticize. Still, there is something about "speech" as a field of scientific inquiry that rings uniquely hollow, as if there were no substance to it other than that lent by outside disciplines. One cannot help but wonder whether a real integration is possible. If so, it would undoubtedly require a greater familiarity with recent research developments in science than these authors exhibit. At least as to psychology and physiology, their treatment is anything but modern. Their theories of pitch and intensity discrimination are unjustifiably antiquated, because relatively modern sources are quoted in other connections.

This criticism should not imply that the volume is quite useless. It is carefully written, readable, and probably contains enough information to keep a college student busy. It also contains many exercises for vocal drill, some of which look as if they might be useful if carried out under supervision.

S. B. WILLIAMS

THE INVISIBLE WORLD.
By Hereward Carrington. The Beechhurst Press, Barnard Ackerman, New York. $2.50. 190 pp. 1946.

The "invisible world" of which Carrington writes is the world of spirits. The search for evidence of this world takes the reader from haunted houses (with or without benefit of a few stiff drinks) through Mrs. Piper and Jeanne D'Arc to the teachings of the Yoga philosophy. Some of the data which convince the writer of the reality of "psychic phenomena" come from "drawing rooms in London and Paris and New York" (p. 12), reports of the kind of mysterious manifestation experienced by perhaps 12 million persons (and a number of dogs—see p. 23) in the United States alone; some from laboratories for the study of psychic phenomena. The expansion of the latter source is felt to be "one of the prime needs of our time" (p. 7), for psychic science "is doubtless destined in the near future to rule and dominate the whole world of thought, and to influence the belief of humanity as to its ultimate destiny and the meaning of life!" (p. 148). Already some of the results of such work "have caused a whole group of scientific men in Europe to speak of the new science of supernormal biology" (p. 56).

If one were to approach this book skeptical of spiritism, his doubts might be increased by some of

the stories recounted and the fraudulent techniques revealed. In fact, the negative instances might seem to outweigh the allegedly positive cases, suggesting, by the application of the doctrine of parsimony, that the apparently mystical occurrences deserve a more earthly interpretation, or at least more objective observation. But whatever explanation is presently most appealing, Carrington is quite justified in the implication that the *a priori* attitude that "it simply cannot be" is no less out of place in science than is careless control of relevant variables. It is questionable that this book will make the tilting table a standard piece of biological or psychological laboratory equipment, but it may at least be a reminder that the basis of science is experiment and controlled observation, rather than emotional preconception and dictum. When the scientist comes wholly to accept the truth of this principle, he may have greater success in converting the spiritualist to it.

FRANK W. FINGER

HINDU PSYCHOLOGY: *Its Meaning for the West.* *By Swami Akhilananda. Introduction by Gordon W. Allport; foreword by Edgar Sheffield Brightman. Harper & Brothers, New York and London.* $2.50. xx + 241 pp. 1946.

"Equivocation"—the confusion of diverse concepts because they bear a common name—is not only an everyday cause of illogical thinking and needless argument, but also a constant source of irritation to workers in technical fields which share the layman's vocabulary. More than one teacher of college courses labeled "Psychology," tiring of esoteric questions raised in the name of *psyche*, has proposed that a new title be adopted for his discipline. The inertia of language has prevailed, however, and as a consequence "psychology" is used to designate anything from the photochemistry of the retina to the transformation of the soul after death. Hence it is that the book called *Hindu Psychology* touches no more than a tiny corner of the field of American Psychology, and extends in a direction which the experimental psychologist feels he cannot follow without violating the methodological definition of his science.

This book, in other words, has little relation to the bulk of objective research precisely called psychology. Indeed, its basic tenets are incompatible with the principles underlying science as we understand it to be. Probably it approaches more closely the technical field of psychotherapy. In essence, it is a fluent and intelligible description of Vedanta, the philosophy or religion of Hinduism. It is an Eastern counterpart of Rabbi Liebman's *Peace of Mind.*

Yet though Swami Akhilananda's discussion may be lacking in science, it does not follow that it is devoid of significance for the scientist. In the first place, no thinking citizen of a shrinking world can afford to remain ignorant of the basis of action of such a large sector of the population. A people devoted more to "meditation and concentration" than to technological gadgetry cannot be blandly fitted into a pattern conceived from the Occidental viewpoint. Secondly, both society and the individual can profit by accepting the suggested clues to increased happiness and improved mental hygiene: the integration of the numerous vectors of life, and the subordination of material to inter-personal or spiritual values. Finally, it is well that the scientist should occasionally be brought to realize that his specialized technique is not the only method, nor even necessarily the most fruitful method, for interpreting nature. If the Swami does nothing more than challenge us to examine critically our complacently accepted way of living and learning, his contribution will have been worth much.

FRANK W. FINGER

MEN AT WORK. (*Second Impression*). *By C. A. Oakley. Hodder and Stoughton, and University of London Press, London.* 8s. 6d. xii + 301 pp. + 7 plates. 1946.

The author is the Director of the Scottish Division of the National Institute of Industrial Psychology, and Lecturer in Industrial Psychology at Glasgow University. During the past few years, he has been asked to deliver addresses before various groups and organizations on the problems of industrial psychology. Feeling the need for some book to bring together many of the related problems and facts, he has written down much of what he has been talking about in a form which should appeal to both layman and professional psychologist.

The book is organized into nine chapters, the last of which is a summary of the material covered in more detail in the earlier chapters. The chapters cover most of the general topics in the field of industrial psychology, including problems of management, selection of personnel, training, fatigue, the physical environment, and efficient work habits. Far from being a ponderous collection of facts, Oakley has written in a delightful style, one which makes the reading a real pleasure. At no time does the author lose you in a welter of unexplained facts. No psychological background is necessary to understand this book, although sufficient real facts are given to make it profitable for the industrial psychologist to spend his time on this book.

As a matter of fact, the book is not at all heavily documented, and at times one could almost wish that more facts were presented. Much of the book, particularly the earlier sections, is well endowed with

common sense, and common sense is not to be decried in a field where there are so few established facts. Particularly is this true when the author's common sense, as so often, seems to agree with the reviewer's.

The earlier, more philosophical sections, on the motivation of the worker and on employer-employee relations, are the least good. The later sections, on the work environment and worker efficiency are quite good, however, and neatly cross the fields of psychology and industrial engineering.

W. R. GARNER

PSYCHOLOGY IN HUMAN AFFAIRS. *McGraw-Hill Publications in Psychology.*

By J. Stanley Gray, with the assistance of eleven contributors. McGraw-Hill Book Company, New York and London. $3.75. viii + 646 pp.; ill. 1946.

This is a college textbook in applied psychology. It contains 18 chapters, 7 of which were written by the author and 11 by other contributors. The chapter headings and their authors are: Introduction (J. S. Gray); Psychology in College Life (J. S. Gray); Psychology in Child Development (J. S. Gray); Psychology in Education (J. S. Gray); Psychology in Vocational Guidance (J. S. Gray); Psychology in Human Adjustments (J. S. Gray); Psychological Effects of Nutrition, Drugs, Alcohol, and Tobacco (Erma T. Wheeler); Psychology in Mental Illness (Paul A. Brown); Psychology in Speech Correction (J. S. Gray); Psychology in Public Opinion and Propaganda (Ross Stagner); Psychology in Crime (David B. Rogers); Psychology in Music, Art, and Leisure (Gunborg Berglund-Gray); Psychology in Industry—Employment (Stanley E. Seashore); Psychology in Industry—Training and Merit Rating (Stanley E. Seashore); Psychology in Work and Efficiency (Alfred G. Dietze); Psychology in Business (Martha Ann Blosser); Psychology in Military Affairs (George L. Fahey and Murray M. Mintz); and Psychology in Clinical Practice (Carroll A. Whitmer).

As frequently happens when texts are prepared by many contributors, this volume has both gained and lost something because of its multiple authorship. It has gained because the book as a whole is probably more factual and authoritative than it would have been had one man tried to prepare it. A great diversity of topics is covered, and it would have been difficult for one man to do credit to them all. A few of the contributors are also well-known specialists, writing about their fields of special competence.

But multiple authorship also has its disadvantages. This book lacks continuity—in style of writing, in material, and even in the order in which the chapters are arranged. These are indications of insufficient editorial supervision by the senior author. The last chapter, for example, is obviously misplaced. There are very few cross references in the text to relevant material in other chapters and, in some cases, the same material appears in several chapters. Some of this duplication is annoying. Thus, the extremely simplified discussion of how an IQ is computed should have been eliminated from the last chapter, especially since the IQ is mentioned in nearly every one of the preceding seventeen. Then, too, the chapters differ widely in their quality. Some, e.g., the ones on speech correction, public opinion and propaganda, and psychology in industry, are meaty and solid. They contain many factual and experimental data, and are well written and interesting. Others, e.g., the ones on music, art and leisure, military psychology, and clinical psychology, are, frankly, disappointing.

Lest the reader be misled, however, this is a good text in applied psychology despite its shortcomings. During the past two decades, psychology has become more practical, more inclusive, more factual. This text tells us how psychology has contributed directly to the understanding and management of human affairs. The volume is not as complete nor as advanced as Poffenberger's *Principles of Applied Psychology*, for example, but it should be a good text for undergraduate students at a fairly elementary level. It can also be recommended to laymen who are interested in learning about applied psychology in an authoritative, but less academic, treatise than most of those in this field.

A. CHAPANIS

THE DYNAMICS OF HUMAN ADJUSTMENT. *The Century Psychology Series.*

By Percival M. Symonds. D. Appleton-Century Company, New York and London. $5.00. xvi + 666 pp. 1946.

In the course of working up lecture notes for a class in mental hygiene, the author of this book read about 2500 references that ranged from Freud's tomes to short abstracts of research reports. Of these, 883 are contained in a usefully annotated bibliography at the end of the book. Of these 883, 46 are by Freud himself and many more are by what are loosely called Freudian writers. On the whole, the book appears to be a much-too-little-edited and undigested version of the author's reading notes.

On page xi, Symonds says that his point of view is "frankly psychoanalytical." Yet on another page (ix), he has said, "This book is a systematic treatment of the principles of the dynamic psychology of human adjustment and motivation. It carries on the tradition of dynamic psychology at Columbia University initiated by Woodworth and Thorndike, but not

exactly along the lines of its predecessors." If this be true, Columbia University has been carrying on entirely too many traditions under the same name. Of all misused words, "dynamic" is probably the most frequent. Symonds glibly contrasts his dynamic psychology with behavioristic and gestalt psychology, by neatly assigning the latter pair to "observable behavior" and "the way an individual perceives his world," respectively, and reserving for his own interests the study of how an individual "adjusts to the situations that he confronts."

One could overlook these half-truths if Symonds only had bothered to continue another old tradition, supported by Woodworth and Thorndike, that of presenting evidence for conclusions. What will Thorndike think, for example, of such statements as, "since guilt represents a conflict within the person, any signs of conflict are disorganization are prima facie evidence of guilt" (p. 372)? A similar disregard of evidence *and* logic appears on nearly every page. Symonds himself has apparently noticed the disturbing lack of evidence and in his preface he forewarns psychologists, saying that they well may be disappointed because of the book's dogmatic character. He assures them that, though experimental evidence is admittedly lacking, nevertheless the material is firmly based on close study (clinical) of individuals—Freud's studies, mostly.

Now, psychologists can read Freud for themselves; it's better in the original anyway! They also can read Woodworth and Thorndike. The few who do read Symonds will very likely be disappointed, just as he predicts, not alone because of the lack of evidence for his conclusions, but because of his loose and unsystematic treatment as well. Who, then, will read the book? College students, presumably—and as a college text it is almost sure to be seriously misleading, as well as discursive and shallow.

In favor of the book, it may be said that it does discuss some very important matters that need thorough discussion. Its aim is essentially sound: to attempt an integration of Freudian and other principles of behavior. The enormity of the task has defeated many others before Symonds. The task is a huge one and is not likely to be completed so easily and quickly as the author imagines.

S. B. Williams

People in Quandaries: *The Semantics of Personal Adjustment.*

By Wendell Johnson. Harper & Brothers, New York and London. $3.25. xiv + 532 pp. 1946.

The author outlines in this book the bases of general semantics and its uses in maladjustment problems. He makes a plea for the use of such language in ordinary life as scientists use (or should use) in dealing with scientific material, in order to discourage that use of language which serves to obfuscate issues instead of illuminating them. He states: "The fundamental thesis of this work is simply that science, clearly understood, can be used from moment to moment in every day life, and that it provides a sound basis for warmly human and efficient living." (He means scientific method, not technology.) The language of science must be used meaningfully, and the terminology of the question determines the terminology of the answer.

Maladjustment, according to the author, lies in mistaking the verbal record of the past for the description of the present. He illustrates by referring to numerous prejudices and neurotic reactions. The highest use of language lies in abstracting, and from its abuse arise the evidences of personal and social maladjustment.

So far, all is good sense and helpful to accurate thinking. Less helpful seems to be the chapter on techniques and practical devices, with the resort to Jacobson's relaxation and Korzybski's semantic relaxation methods. Just what do these methods prove, and how do they aid materially in semantic clarity?

After discussing the language of maladjustment, Johnson describes the standard types of maladjustment, both neuroses and psychoses, in thumbnail sketches, which do no great violence to traditional thought on the subject. In the chapter on treatment, he discusses "cases"—instead of patients—and one gets an unpleasant semantic shock from his use of the term.

In summary: the author gives an excellent statement of the use and misuse of language in everyday life and in psychopathologic states. That this can be used for any purpose other than to point a finger in the direction of the underlying motivations, and to clarify to the patient these facts, is doubtful.

Wendell Muncie

Aftermath of Peace. *Psychological Essays.*

By A. M. Meerloo. International Universities Press, New York. $2.50. 218 pp. 1946.

The author, from his personal experiences in occupied Holland, discusses some aspects of the present problems of all those who were victims of German aggression, cruelty, and lust for power: e.g., the problem of treason and traitors, of hatred and collective hatred, or of fear, problems of displaced peoples, problems of European children, etc. All this finally leads to a plea for psychological "peacefare" as thorough-going and resourceful as was psychological warfare. Meerloo indicates the psychological sources of the trials and tribulations in the development of a one-world program, and concludes, as any sane person must, that to

gain collective security the State must accept a reduction of its power.

WENDELL MUNCIE

STUDIES OF COMPULSIVE DRINKERS. *Part I. Case Histories. Part II. Psychological Test Results.* *(I) By Herman Wortis and Leonard R. Sillman; (II) by Florence Halpern; edited by Jane F. Cushman and Carney Landis; foreword by Nolan D. C. Lewis. Hillhouse Press, New Haven; distributed by Quarterly Journal of Studies on Alcohol, New Haven.* $1.00 (paper). vi + 90 pp. 1946.

This booklet records the results of a rather intensive study of eighteen chronic alcoholics, studied psychiatrically, in Part I, through use of the conscious, ventilating, usual history of each patient, and later, in Part II, by a practical competent psychologist through a battery of tests selected so as to place emphasis on the possibility of at least partially revealing the dynamics of the personality, rather than a mere enumeration of personality traits. Although, in the Summary and Conclusions, the statement is made that "on the basis of the psychological test results, the alcoholic appears to be a poorly adjusted, unstable, restless individual"; yet one finds, in the Foreword, that Nolan D. C. Lewis has stated that "the differences between the personality structures of the alcoholics and of the individuals in the normal control group were most intangible." The reviewer feels, in accord with Lewis, that "if these histories should be of value to students of the problems of alcohol, then the study will have been justified and the confidence and cooperation of the individuals who provided their histories will have been rewarded."

ROBERT V. SELIGER

A PSYCHOLOGIST LOOKS AT SEX.

By Howard L. Philp. Hutchinson's Scientific and Technical Publications, London, New York, Melbourne, and Sydney. 8s. 6d. 110 pp. 1945.

The author of this book has attempted to develop a rather personal concept of the meaning of sex, including its individual and social implications. He has succeeded in presenting a concept of sex which is accepted generally as being mature, healthy, and rather conventional. The scientific approach implied in the title and given lip-service in the text is often colored by moral and philosophic attitudes. The section entitled The Lover's Responsibility is concluded with "the end of life and its finest values are only found when the body becomes the expression of the spirit." More directly, it is stated that psychology has failed to consider "the real and whole nature of man. Because it (psychology) has consistently failed to do so in relation to love and sex, we look to the poets, artists, musicians, and to those with religious insight for light."

Accepted as a considered personal view rather than as a scientific treatise, the book should be of value to the interested layman.

LOUIS F. CLEARY

SEX IN OUR CHANGING WORLD.

By John McPartland. Rinehart & Company, New York and Toronto. $2.75. viii + 280 pp. 1947.

This book is undoubtedly destined for a big sale. It has been most favorably reviewed in the general press, and its subject, of course, has the widest possible popular appeal. As books on sex go—there seems to be an endless flood of them, running particularly strong just now—the present example is not a bad one. The author writes with wit and gusto, appropriate to his subject, and calls a spade a spade. In style, he approaches at his best the inimitable reporting of Frederick Lewis Allen, whose *Only Yesterday* covers essentially the same period and scene as the present book. But McPartland overdoes the matter—he is never satisfied to say something simply. He must be forever witty, always brilliant. The reader will smile and chuckle over the telling shafts of the first few chapters, but a feeling of surfeit is likely to ensue, so that the remainder of the book will have to be taken in smaller doses.

McPartland is a keen and brilliant observer and reporter of conditions. He has not the objective attitude of a trained sociologist, however, and he makes no effort to substantiate his opinions. He generalizes broadly on the basis of his own knowledge. Perhaps he is always right in his analysis of our changing attitudes toward sex, from the time of the first World War to that of the second. A scientist may be pardoned a doubt and a wish for more evidence than is cited. To one, at least, who was in college in the 'twenties, the author's graphic descriptions of the sexual ways of that epoch seem true enough for a portion of the younger generation, but hardly for the majority thereof. McPartland, of course, inserts a cautioning word now and again, but the constant emphasis on the most sexually distraught elements of the population yields an overly lurid picture. In any case, you will want to read the book!

BENTLEY GLASS

SEX PROBLEMS OF THE RETURNED VETERAN.

By Howard Kitching; foreword by Ernest R. Groves. Emerson Books, New York. $1.50. 124 pp. 1946.

This small book is another one of the helpful, informative volumes which is designed primarily to aid the returning soldier and his wife. Particularly in the sexual sphere does it help, since it has been recognized for many years that war creates an abnormal sexual situation that can indeed be called a hazard to the adjustment of the returning soldier.

Kitching discusses rather lucidly such problems as the goal in marriage, the husband's problems, and the wife's problems. Of particular significance is the portrayal of the differences arising when the prospect of reunion and the reunion in reality are not congruous. Many times during the war those who served as medical officers with Army and Navy units would come into contact with the "Dear John" letters. These were letters to men who, while fighting for their country, were told that wife or sweetheart had found another man to love and desired a divorce or separation. The book quite well describes the temptations that the woman who was left at home had to face, and the author brings out the point that, although it is quite easy to get involved in an extramarital affair, it is often quite difficult to get out of it.

The author's style is simple, and no technical terms are used. Kitching has brought out into the open the majority of the problems faced not only by the returning soldier but also by those who have married after returning from the war, so that the book will serve as a helpful guide on innumerable bookshelves. A very good foreword to the book was written by Ernest R. Groves, Professor of Sociology at the University of North Carolina.

ROBERT MAZER

LEONARDO DA VINCI: *A Study in Psychosexuality. By Sigmund Freud; authorized translation by A. A. Brill. Random House, New York.* $2.50. iv + 121 pp. + 2 plates. 1947.

This translation of Freud's most famous analysis is triply welcome, first, because it has been unavailable in English for more than fifteen years, second, because the translation and Introduction are by America's foremost authority on Freud, A. A. Brill, and lastly, because it is an exceptionally fine example of good printing and bookmaking.

JEALOUSY: *A Psychiatric Study. By Boris Sokoloff. Howell, Soskin, New York.* $2.50. 263 pp. 1947.

In this poorly written book, Boris Sokoloff defends the highly debatable thesis that "Jealousy is not only inbred in human nature but is the most basic, all-pervasive emotion which touches man in all aspects of every human relationship." Relying heavily on the persuasive power of italics, Sokoloff maunderingly amplifies his position on the subject of jealousy into 15 self-styled "basic facts." It is hardly worth while to list all of them, but a sampling may give an idea of what the reader will find:

"Basic fact" number one: "There are 3 degrees of jealousy: jealous reaction, jealous sentiment, and jealous complex."

"Basic fact" number three: "Jealous reaction stems from the adrenosympathetic system and belongs to the same group of reactions as fear or anger. It is associated but not identical with the instinct of acquisition or ownership."

"Basic fact" number seven: "Jealous sentiment appears among children when there is a constant occurrence of jealous reaction. The same is true among adults. Yet the jealous sentiment of a child is of a temporary nature while in an adult it tends to form a jealous complex."

"Basic fact" number eight: "The formation of a jealous complex from jealous sentiment depends on the mental predisposition of the person. A neurotic is apt to form a jealous complex often on the slightest provocation. Like many other complexes a jealous complex is, in almost all cases, a repressive one."

It is difficult to comment constructively on the author's intellectual position, so curiously free from any effect of modern psychiatric thought or theory is his thinking. He seems to have been mildly affected by the semantics but never by the real content of bona fide psychiatry.

Following his 55-page exposition of "What is Jealousy?", Sokoloff plunges into tabloid case after case, in which ladies with "steely grey eyes" or "stubborn mouths" murder, maim, and make suicidal attempts motivated entirely by all-inclusive jealousy.

The final chapter, which begins luridly with: "A pistol lay beside the two bodies that were discovered one morning of this year in the front yard of the residence of a professor of Ohio State University," is entitled "How to Treat Jealousy." It is a sanguine thought to learn that there is some treatment for the multiple forms of violent aggression Sokoloff has described with such relish. However, his suggestions of what to do before the bodies appear are rather lame. For example, he says, "If a mother is aware that some boy is jealous of her girl, she should promptly stop their romance." There is no consideration of the intricate motivations of adolescence in love, and the complications which will beset any mother who wishes to interfere with a romance are cheerfully dismissed.

Without probing into the sincerety of the author's intentions, one can only say that his work produces the effect of having been written for sensationalism under the guise of psychiatry, in order to appeal to the most untutored intellect. It is the sort of travesty on clinical reporting and on psychiatric thinking that is

usually associated only with the Sunday newspaper supplements. To find it dignified in book form is an unpleasant surprise.

HELEN HEWITT ARTHUR

ARE YOU CONSIDERING PSYCHOANALYSIS?

Edited by Karen Horney. W. W. Norton & Company, New York. $3.00. 262 pp. 1946.

Are You Considering Psychoanalysis? is written by Karen Horney and five of her associates. The book attempts to answer various pertinent questions posed at one time or another by everyone who thinks of the possibility of investing in a psychoanalysis. These questions serve as the springboard for rather verbose discussions, heavily weighted, understandably, toward the Horney school of thought.

The nine questions dealt with in separate chapters are "Why Analysis?", "What Schools of Psychoanalysis Are There?", "What is a Neurosis?", "What Are Your Doubts about Analysis?", "Who Should your Analyst be?", "What Do You Do in Analysis?", "What Does the Analyst Do?", "How Does Analysis Help?", and "How Do You Progress After Analysis?" These are certainly important issues to be clarified for the analytic prospect, and the authors, all practising analysts, approach their self-appointed task of clarification with competent zeal but no very great inspiration. Even the two chapters by Karen Horney somehow seem rather static.

Since this book was assembled primarily for the edification of the laity, it is perhaps unfair for anyone moderately sophisticated in psychiatry to judge it. However, it seems to me that in their commendable effort to present all aspects of the questions they consider, the authors have become overly involved in the jargon and the generalities of the trade. It is just possible that the intended reader will become confused instead of being enlightened. The tone of the writing, though, is uniformly optimistic and positive—if the right analyst and the right patient work hard enough on the right problems all is sure to go well—and the analysand-to-be may find this reassurance regarding the value of psychoanalysis enough for his money.

This book is not designed to make any psychoanalysis easier or shorter. As the authors carefully point out, questions highly charged with emotion, and indecisions about such a therapeutic procedure as psychoanalysis spring from neurotic anxieties. These cannot be dispelled by reading over even a Horney analyst's point of view on them. The book is, rather, oriented toward the superficial education of the individual, so that he may feel, as he contemplates psychiatric help, as if entering into a program for which there are definite rules by which and realistic goals toward which he and his physician will work.

HELEN HEWITT ARTHUR

THE YEARBOOK OF PSYCHOANALYSIS. *Volume 2, 1946.*

Edited by Sandor Lorand. International Universities Press, New York. $7.50. viii + 280 pp. 1946.

It is gratifying to see the second volume of the *Yearbook*. This year, Sandor Lorand and his staff have collected a group of papers of a wide variety of interest, including special therapeutic and sociologic problems, biographic notes, and a paper on psychosomatic phenomena, the latter an excellent contribution of the late Otto Fenichel. A glance through the table of contents gives one some idea of the calibre of work to be anticipated, as it includes outstanding, well-known individuals in the field, e.g., Fenichel, Deutsch, French, and Jones. Three of these, including Fenichel, who contributed two articles to the volume, have died during the past year. It would be of little use to draw attention to any particular article. Each seems to have been adequately handled.

It is to be hoped that these volumes will continue their work of gleaning from the outstanding papers of the year, and providing so excellent a review of annual progress in the field, along with an occasional side article or classic article of interest to those in psychoanalytic work.

LUCILLE CARTER

THE AMERICAN PSYCHOLOGIST: *The Professional Journal of the American Psychological Association, Inc. Volume 1, Number 1, January 1946. Monthly.*

Edited by Dael Wolfle. The American Psychological Association, Baltimore 2 (Mt. Royal and Guilford Aves.,) and *Washington 25* (2101 Constitution Ave.). Subscription: $7.00 a year; single copy 75 cents.

Excellently printed on high grade paper, this new professional journal is to contain "articles on the training of psychologists, their duties, opportunities, employment, and other professional matters. In it will appear APA programs, proceedings, and presidential addresses. Sometimes it will contain similar material from the APA divisions or from regional psychological societies. It will continue the functions of the 'Psychology and the War' section of the *Psychological Bulletin*, and will publish the remaining articles in series which started in the *Bulletin*. Special sections of notes and news, obituaries, a calendar of coming meetings, and reports from the APA office will be regular features." The first issue contains

three articles (The Reorganized American Psychological Association, by Dael Wolfle; Psychological Research on Pilot Training in the AAF, by the Staff of the Psychological Research Project (Pilot); and State Psychological Societies, by Roy M. Hamlin and Stephen Habbe) and four departments: Across the Secretary's Desk; Obituaries; Psychological Notes and News; Convention Calendar.

HUMAN BIOLOGY

THROUGH THE STRATOSPHERE. *The Human Factor in Aviation.*

By Maxine Davis. The Macmillan Company, New York. $2.75. viii + 253 pp. 1946.

This is a book for laymen on the subject of aviation medicine as it pertained to the Army Air Forces in World War II. Aviation medicine begins, for the flyer, with selection and classification. Of the six sections in the book, each including from one to nine chapters, the first deals with the story of assembly-line applied psychology—the process of cadet selection. Subsequent sections deal with the effects of altitude upon the body, with specific human problems of combat flying, with survival and rescue in the jungle, with the methods of caring for, and curing men whose minds have broken for a time as a result of the impacts of combat. The final section tells the story of air evacuation, hospitalization, and the role of flight nurses in this phase of aviation medicine.

In each chapter, the technique of telling the story is the same: first, state the problem; then give examples to illustrate; finally, tell the solution which the Air Forces Medical Services adopted. If all the foregoing seems mundane, it should be said that Maxine Davis tells about them in an easy, reportorial style. She had expert guidance along the official line through headquarters, AAF, and a number of the combat forces, and travelled more than 35,000 miles by air, from Europe to China, all in the space of two months' time. If, therefore, *Through the Stratosphere* seems superficial and uncritical to those who shared in one or another aspect of the programs of activity described in this book, one still cannot deny that it does tell effectively, in a short space, the best side of the story of aviation medicine in the recent war. It is a record of accomplishment which will interest a wide variety of readers.

S. R. M. REYNOLDS

ARCHAEOLOGY OF ALKALI RIDGE, SOUTHEASTERN UTAH *with a review of the prehistory of the Mesa Verde Division of the San Juan and some observations on archaeological systematics. Papers of the Peabody Museum of American Archaeology and Ethnology, Harvard University, Volume XXI.*

By John Otis Brew. Appendices by Alice Brues and Volney H. Jones. Peabody Museum of American Archaeology and Ethnology, Cambridge. $10.00 (cloth); $7.50 (paper). xvi + 346 pp. + 56 plates; text ill. 1946.

This monograph does several things. It presents in detail the findings at Alkali Ridge and discusses them in relation to the rest of the Southwest. It also presents an evaluation of Southwestern archeology at the present moment, and of the role of taxonomy in science in general and in archeology in particular. Such breadth of coverage and outlook makes this monograph valuable not only to the Southwestern archeologist, but to all people interested in American prehistory and to those scientists who enjoy study of the philosophy underlying scientific work.

The work at Alkali Ridge was designed to fill in our knowledge of Pueblo II developments. A series of village sites were excavated. Tree ring material for dating the sites was found, as well as abundant pottery useful for correlating the developments here with other areas. The critical pottery find was the occurrence here, in early levels, of red ware. These sites are in the heart of the Pueblo area, which has always been described as characterized by black on white wares. Brew is most careful to avoid final conclusions in the present state of our knowledge. He discusses the possibilities of southern influence, e.g., from the Hohokam or the Mogollon, and though he does not rule them out as a source for the red ware, he thinks local development an equally good probability.

In this case, as in many others, Brew goes to great lengths to show the value of multiple hypotheses and to stress that even in this area, by far the most intensively worked in America, we do not know nearly enough to be sure of place or time of origin of most traits, and hence cannot speculate very profitably as to the time and direction of diffusion.

Brew is very critical of the use of taxonomy in the Southwest. He finds that the establishment of tentative periods characterized by tentative traits tends to become a fixed system into which all materials are forced. He notes that most of the several systems used in the Southwest have been constructed on biological principles, and points out that such principles have very limited application in social science. A telling example is to be found in architecture. Certain structural types are often spoken of as characterizing each culture period. Brew's excavation has shown that, far from being a whole limited to a distinct period, a single house may have each wall of a different "diagnostic" type.

Other points of note: in reviewing the basic cultures of the Southwest, Brew accepts the Anasazi (Basket Maker Pueblo) and the Hohokam. The Patayan

(Yuman?) he considers as not yet established but likely to be real. The Mogollon he thinks is not yet established, and one gathers that he rather doubts that it will be, at least in the terms by which it has been defined to date.

The Basket Maker and Pueblo cultures were formerly thought to be represented by two different physical types and to have a major cultural break between their respective periods. Brew shows that actually there is a cultural continuum. This agrees with the findings of Seltzer (Racial Prehistory in the Southwest and the Hawikuh Zunis, *Peabody Museum Papers*, Vol. 22, No. 1) that the Basket Maker physical type has persisted unchanged down to the present. Thus is exploded one of the "axiomatic" teachings of college anthropology.

Important points concerning the presence or absence of irrigation in the Southwest are raised. It has long been assumed that well developed canal irrigation was characteristic of the Pueblo culture. Brew tends to follow this assumption. Many "reservoirs" are mentioned at the Mesa Verde site; but if these were really reservoirs at all, they may have been for collecting drinking water, as has been proven at other sites. Much of the difficulty of interpretation arises from the lack of sharp definition of terms and the absence of detailed observation by workers with some agronomic knowledge.

There is an appendix by Alice Brues, giving measurements of skeletal material and observations of pathology and anomaly. She concludes: "The picture evoked is that of a population suffering from two primary evils, malnutrition and hostile attack." This is in considerable disagreement with other evidence.

There is also an appendix by Volney Jones on the plant materials recovered. These consist primarily of corn and beans, most of it charred. Significant finds: possibly tepary beans (*Phaseolus acutifolius*), possibly lima beans (*Phaseolus lunatus*), common beans (*Phaseolus vulgaris*), dent corn, crescent seeded corn, 12- to 14-rowed ears; all in Pueblo I. These are the earliest reported finds of tepary and lima beans in Pueblo sites. Carter has linked the tepary bean to the Hohokam culture and has also attempted to link the lima bean to that culture. These materials indicate early, direct diffusion.

This important paper is useful both for the specialist and the more general reader. It is written in an easy, at times even sprightly, style. For Americanists it is required reading. Its more general chapters can be recommended to all.

GEORGE F. CARTER

EXCAVATIONS AT APATZINGAN, MICHOACAN. *Viking Fund Publications in Anthropology, Number Seven.* *By Isabel Kelly. The Viking Fund, New York.* $3.00 (paper). 227 pp. + 24 plates, 1 map, and 6 charts; text ill. 1947.

Apatzingan, in the Tierra caliente of the Mexican state of Michoacan, is the latest locality to be covered in a series of reports on the archeology of West Mexico by Isabel Kelly. Despite her work, the archeology of west Mexico is still poorly known, and this present material can be but weakly related to work in other parts of the area. Her own words indicate a happy evaluation of a situation that would discourage a less stout-hearted person: "One of the peculiar satisfactions of working in West Mexico comes from the fact that it is a zone where we still do not know all the answers. Many years of survey and excavation will be necessary before this happy goal is attained." Increasing interest in the area today, with more workers entering the field, assures that the work now being done will eventually be fitted into a coherent picture.

The objectives of the work were "to define as fully as possible, both as to ceramic and other manufactures, such cultural complexes as occur in the immediate vicinity of Apatzingan; in the second place, to arrange these complexes in chronological sequence. Although the results of such a program would be limited in significance to one small area, they should provide a concrete scheme to which subsequent work in surrounding zones could be related." The work is accordingly presented as follows: the natural background; the historical records; the ceramic complexes; miscellaneous manufactures; excavations; mortuary customs; conclusions.

The general conclusions are: Apatzingan represents an island of local cultures. Some of this uniqueness will decrease as more is learned about the adjacent areas. Apatzingan shares many fundamentals with other Mexican cultures, but the sources of these influences and their routes are unknown. The later horizons can be equated roughly with known horizons from Colima and Tuxcacuesco. The earliest complexes at Apatzingan seem to be somewhat earlier than those of Colima and Tuxcacuesco.

GEORGE F. CARTER

EXCAVATIONS IN THE CUENCA REGION, ECUADOR. *Yale University Publications in Anthropology, Number Thirty-five.* *By Wendell C. Bennett.*

BRITISH GUIANA ARCHEOLOGY TO 1945. *Yale University Publications in Anthropology, Number Thirty-six.* *By Cornelius Osgood. Yale University Press, New Haven; Geoffrey Cumberlege, Oxford University Press, London.* $2.00 (paper). (35) 84 pp.; ill. (36) 65 pp.; ill. 1946.

The Cuenca basin lies in the interior highlands of Ecuador. It is basically a subsistence farming district today, much as it must have been in the past. Historically, it was occupied by the Cañaris. Little archeological work has been done in the area. This report presents data from 18 sites, the principal analysis being based on pottery styles. The various types from each site are described and analysed and compared. There is a review of Ecuadorian archeology. Bennett states: "In final analysis Ecuador as a whole belongs culturally as well as geographically with the northern Andean region, rather than with the central Andean area of Peru and Bolivia."

British Guiana archeology is almost unknown. In the second part of this volume, Osgood surveys the work done to date, and presents some data from his own survey in the area. The earlier work, mainly superficial, was marked by a tendency to draw conclusions not supported by the data. Osgood has related the phenomena reported earlier and those that he observed himself to three peoples, the Arawak, the Carib, and the Warau. The Warau probably accumulated the shell mounds that are poor in pottery. Hilltop sites were perhaps Arawak, and the inland sites with evidence of extensive cannibalism probably were Carib. Osgood's formulation brings a certain amount of order into an area formerly chaotic.

GEORGE F. CARTER

HANDBOOK OF SOUTH AMERICAN INDIANS. *Volume 1: The Marginal Tribes; Volume 2: The Andean Civilizations. Bulletin 143.*

Edited by Julian H. Steward. Bureau of American Ethnology, Smithsonian Institution, Washington, D. C. (1) $2.75; (2) $4.25. (1) xx + 624 pp. + 112 plates + 3 maps; (2) xxxiv + 1035 pp. + 192 plates + 2 maps + 1 chart. 1946.

This handbook provides a concise summary of existing data to serve as a standard reference for scholarly work. It is also invaluable to students and of interest to the general reader. The work is the result of pooling the resources of over 100 scientists. Attention is centered on the culture of each tribe at the time of its first contact with Europeans, but archeological background and post-contact acculturation are often included. It is not possible to review in detail the work of so many men and covering an entire continent; hence merely the plan and scope of coverage are indicated below.

Volume One, *The Marginal Tribes*, deals with the peoples outside the centers of highest cultural development. Part One, dealing with the Indians of southern South America, presents the archeology and culture of the peoples of Patagonia and the Pampas. The Indians of the Paraná delta and the La Plata littoral are separately treated, as are the Charua and the Huarpe. The peoples of the Gran Chaco and of eastern Brazil are extensively described. A great deal of the material summarized here is not readily available elsewhere. The integration and evaluation supplied by the authors is invaluable. For some of the areas and cultures, these articles are the first authoritative integrations attempted.

Volume Two, *The Andean Civilizations*, is a remarkably full treatment of that complex area. A lengthy introduction presents the general picture. This is followed by extensive discussion of the archeology and ethnology of the Central Andes, and by similar sections which treat the cultures of the Southern and the Northern Andes. A wealth of detail is presented for each people under such headings as distribution and habitat, archeology, history, sources, subsistence, housing, dress, transportation, manufacturing, trade, social organization, warfare, life cycle, esthetics, religion, mythology, lore, and learning.

These are but the first two in a contemplated series of volumes. They set a high standard and will be of great utility.

GEORGE F. CARTER

THE INDIANS OF THE SOUTHEASTERN UNITED STATES. *Bulletin 137.*

By John R. Swanton. Bureau of American Ethnology, Smithsonian Institution, Washington, D. C. $2.75 (paper). xiv + 943 pp. + 107 plates + 3 maps + 1 table. 1946.

This fat volume is the work of a man who has devoted the major part of his life to the study of the Indians of the Southeastern United States. There is an introductory section covering the geography of the region, classification of tribes, population, relation of population to natural areas, prehistoric movements, history from the period of first white contact to De Soto, De Soto's expedition, and the post-De Soto period. The tribes are then described individually in a section entitled: Sketches of the Southeastern Tribes and Their Population. Finally, there is a lengthy section topically organized, including, among others: interpretation of tribal names, physical and mental characteristics, food, horticulture, hunting, fishing, domestication of animals, preparation of vegetable foods, housing, clothing, ornamentation, pottery, implements, societal, and ceremonial life. The whole is, therefore, essentially a handbook. Swanton himself says of his work: "The present effort involves in the main a collection of source materials which it is hoped and believed will be of use to future students."

This is unquestionably a source book of tremendous value. Few students will ever attain the familiarity with the relatively inaccessible documentary material

that Swanton has achieved. In presenting not only his own observations from this material, but in quoting in extenso also the pertinent sections of much of this material, Swanton has done a very great service.

One cannot review such a work in detail. Each reader will find sections of special value to him, and each will also find those inevitable flaws that are a part of any work so vast as this. Below are a few remarks on the sections on food and agriculture, where my competence is greatest. For other points of view, readers are referred to the reviews in the *American Anthropologist*, *American Antiquity*, etc.

At various points Swanton refers to heavy forests as restrictive for agriculturists. This seems a misconception. The "heavier" the forest, the fewer trees per acre and the less labor in deadening. The greater the shading, the less weeds when the land is "cleared." Difficult land would not be the heavily forested, but the lightly forested land.

Hariot's account of "beans and peas" is given (p. 269), but the probability that this refers to *Phaseolus lunatus* and *Phaseolus vulgaris* is not caught. Beverley's description of varieties of corn is also quoted at length (p. 274). Swanton departs from standard usage when he calls the "She-Corn" flour corn. The "Dent on the back of the Grain" clearly indicates that this is what we now call dent corn. On p. 296, he again equates dent with flour corn.

The situation in regard to the gourds, pumpkins, and melons in the New World is still confused. *Cucurbita pepo* and *Cucurbita moschata* were preColumbian in North America. It is likely that Beverley's description quoted on p. 275 refers to *C. pepo* (Pompions), *C. moschata* (Cushaws), *C. pepo melopepo* (Macocks, etc.). The gourds are *Lagenaria siceraria*, and Swanton is incorrect in stating them to be postColumbian in the New World. They are, as a matter of fact, widespread in the New World in early archeologic levels, notably in Peru and in Kentucky.

These few flaws are culled from a mountain of useful material, and are not intended to detract from the very great value of this monumental compilation.

GEORGE F. CARTER

SOCIOLOGY OF THE AMERICAN INDIANS.

By S. M. Barrett. Burton Publishing Company, Kansas City, Missouri. $2.00. 142 pp.; ill. 1946. This little book is obviously intended as an elementary schoolbook, and gives the basic data on American Indian culture. It deals with their material culture (food, etc.), social structure (marriage, etc.), and the artistic and religious aspects of Indian life. It also gives a number of historical notes on outstanding Indian warriors. On the level for which it is intended, it seems quite useful and written with love and understanding. It might have been preferable to have included some additional fundamental data, such as, for instance, the fact that the Southeastern Indians were by no means roving savages, but accomplished agriculturists. To deal with Indian art and not to mention the sculpture of the Northwest coast Indians, is also a somewhat fragmentary treatment, even within the narrow limits of so small a book. It is annoying that the author seems not to be familiar with the correct spelling of such elementary terms as monogamy and polygamy, and that he thinks that cocaine is a product of the cocoa tree. The bibliography is, unfortunately, so vague as to be hardly of any practical use.

These shortcomings should be mended in a future edition, because, fundamentally, the little book is a real addition to our educational literature. The illustrations are satisfactory.

ERWIN H. ACKERKNECHT

THE NAVAHO.

By Clyde Kluckhohn and Dorothea Leighton. Harvard University Press, Cambridge; Geoffrey Cumberlege, Oxford University Press, London. $4.50. xx + 258 pp. + 17 plates. 1946.

CHILDREN OF THE PEOPLE: *The Navaho Individual and His Development.*

By Dorothea Leighton and Clyde Kluckhohn. Harvard University Press, Cambridge; Geoffrey Cumberlege, Oxford University Press, London. $4.50. xvi + 277 pp. + 15 plates. 1947.

Although these two books are separate studies, they supplement each other. *The Navaho* contains what is the substance of any classic ethnological monograph: a description and analysis of Navaho technology and economy, of their family and social life, of their supernatural beliefs and rules. A well integrated chapter on Navaho language is a new feature. New, too, is the far more sophisticated, synthetic, and "practical" or "applied" approach. Concrete economic and administrative problems are abundantly discussed, to a certain extent at the expense of detail in "classic" subjects.

It is significant of the emphasis in present-day American anthropology, regarding the role of personality in culture, that what in the classic monograph filled a few pages, mostly under the title of the Life Cycle, has now grown into a whole separate volume: *Children of the People*. The first part of this book consists of empirical conclusions, based on ordinary fieldwork, concerning the Navaho psychology. Baby experiences are extensively used as a background for this portrait, although the authors are wise and honest enough to state (p. 111) that adult Navaho characters correspond by no means to the predictions psychoanalysts would make on the basis of permissive Navaho

methods of baby training. For an understanding of Navaho psychology, *The Navaho*, in describing problems of adult Navaho life, gives a great number of clues, just as valuable as the observations on weaning and nursing problems in the *Children of the People*.

The second part of *Children of the People* reports and analyses a series of psychological tests, applied as part of the Indian Education Research Project, to 211 Navaho children in three different communities. In the opinion of the authors, the results of these tests accord with the empirical results of earlier field work. I cannot help feeling that the conclusions of the book somewhat contradict chapter four, which summarizes the field experiences.

Such differences are well known to occur when the same culture is seen through two different temperaments, and the tests seem not to have eliminated this difficulty. The Navaho emerges from both analyses as a type more imaginative, curious, and realistic than many other Indians; hypersensitive under the cover of stolidity; still fully penetrated by the reality of his supernatural world, and uneasy under the strain and stress of the acculturation process, fully described in *The Navaho*.

Both books try successfully to create in white North Americans a better understanding of dependent people with a different cultural background, and they are most valuable additions to our anthropological literature.

ERWIN H. ACKERKNECHT

TRINIDAD VILLAGE.

By Melville J. Herskovits and Frances S. Herskovits. Alfred A. Knopf, New York. $4.75. xii + 352 + xxv pp. + 4 plates. 1947.

At first sight, the American Negro is completely Europeanized, although on a very low level. White economics and white government have been thrust upon him, as well as white religion, the white family system, and white arts. Yet a closer study of the ex-slaves reveals how much of their original African heritage has survived as simple retention or as reinterpretation. This holds true primarily for the fields of religion, magic, and music. Yet even in the field of family relations, the authors show convincingly that what seems to us a pathological form of the white family is but a normal adaptation of African family systems to the new slavery or post-slavery situation. African survivals first became obvious in Roman Catholic negro communities, e.g., in Haiti or Brazil. That they exist also in Protestant Negro communities, similar to those of our own South, is shown in this study of Toco, a village in the extreme northeast of Trinidad.

The book consists of a description of the economics, family life, religion, magic, and self expression (in lodges, in courts, in songs) of the Toco villagers, and of a lucid analysis of this descriptive material which emphasizes the more general implications of this local study.

The authors are too well known to need any introduction. Their work on the Negroes of North America, Dutch Guiana, Brazil, and West Africa, and the general books of Melville Herskovits on the myth of the Negro past and on primitive economics are alike outstanding in the annals of anthropology for consistency, courage, insight, and industry. *Trinidad Village* is very well written, and on the same high, scholarly level as the other Herskovits books.

ERWIN H. ACKERKNECHT

MEN AND MANNERS IN AUSTRALIA: *Being a Social and Economic Sketch History.*

By J. Alex. Allan. F. W. Cheshire Pty., Melbourne; distributed by P. D. and Ione Perkins, South Pasadena, California. $3.00. 176 pp. + 16 plates. 1945.

This is a very valuable "social and economic sketch history" of the dominion that owes its existence to the fact that in 1776 the British lost their North American dumping ground for convicts, a certain number of whom were political offenders. Well written and well documented, this story of a community which, having barely emerged from the status of a convict settlement run by the ignoble Rum Corps, was shaken by a tremendous goldrush, is not a "nice" story, but it is an eminently encouraging one, as within 150 years the most satisfactory progress has been achieved. If crime were a predominantly biological phenomenon, this would have been impossible. It might be significant for the present-day Australian approach that the author gives rather detailed accounts of Australian accomplishments in the field of sports, but none of those in the sciences and arts.

ERWIN H. ACKERKNECHT

INLAND FARM.

By R. M. Lockley. H. F. & G. Witherby, London. 10s. 191 pp. + 16 plates. 1943.

This book, by the author of *Dream Island Days* and other works, describes in a delightful vein the trials and triumphs of farming an abandoned estate in Wales to produce food, feed, and fiber for the war effort. Ordered, as a safety measure, to evacuate their "Dream Island" in September, 1940, the family transported their livestock, farm equipment, personal effects, and 4,000 pickled gulls' eggs to their new home.

Government credit, subsidies, and advice enabled the author to secure the necessary equipment and help. With an old tractor, a team of horses, four regular helpers, and extra help at harvest time, more than 120 acres of grain, hay, fiber flax, and potatoes were grown and gathered.

The author presents an excellent picture of the farming methods prevailing in western Wales in wartime. To an American these methods appear to be very tedious. The author's handicaps to effective farming seemed to stem mostly from difficulties and delays in obtaining promised Government aid, and in complying with rigid Government regulations. The pulling of 13 acres of flax required seven days for a crew consisting of 50 untrained Royal Marines. Hunting and trapping the hordes of rabbits found on the farm furnished frequent diversion from farm tasks.

The natural history of the region is well described.

JOHN H. MARTIN

THE POPULATION OF CALIFORNIA: *A Report of a Research Study Made by Authorization of the Board of Governors of the Commonwealth Club of California.* *Commonwealth Club of California, San Francisco.* $2.05 (cloth); $1.54 (paper). xii + 235 pp. 1946.

This chiefly statistical study, based on census data, was made under the direction of Davis McEntire. It deals with the rapid population growth of California, the waves of migration to California at different periods during the last hundred years, and the composition of the population of California according to race, age, and sex. This detailed and thoroughly documented report is of interest primarily to Californians and contains much information of value to sociologists, historians, and students of vital statistics.

During the century following American occupation the population of California increased from a few thousand to over eight million, chiefly on account of continued immigration. As late as 1940, nearly two out of every three Californians had been born outside the state. Old people form an unusually large proportion of the state's population and children are comparatively scarce. Non-white "racial" groups have a sadly smaller life expectancy than the white population. In the former, the death rates from tuberculosis, pneumonia, and children's diseases are much higher than in the latter; but heart disease and cancer are more prevalent in whites than in most of the minority groups. It is very difficult to determine to what, if any, extent these contrasting death rates express differing racial susceptibilities to the various diseases, since they are undoubtedly greatly influenced by differing social conditions and age compositions.

A. H. SCHULTZ

THE CHILD IN THE CITY: *The Hiram House Study of Tomorrow's Citizens and How They can be Developed.* *By Nathaniel R. Howard. The Hiram House, Cleveland.* 20 cents (paper). 46 pp. 1945.

This is an enthusiastically presented short story of how Cleveland's Hiram House staff, led by George Bellamy, made a survey of certain school children and their families in the city, over a period of years. Through this study Bellamy was able to draw some practical conclusions as to how a city child can and should develop in seven basic spheres. His survey served not only to collect data on conditions as they exist but also as an educational medium for promoting sound health and personality programs for the children studied.

This study has proved so useful in improving the total adjustment level of the under-privileged youngsters involved that the settlement house now intends to extend this into-the-community program still further. This is a most laudable enterprise and surely is something which any city would do well to emulate. Many cities, however, are not fortunate enough to have a social leader of George Bellamy's stature to organize and promote such a highly integrated and far-reaching scheme.

HELEN HEWITT ARTHUR

LES RACES HUMAINES. *"Que Sais-Je?" Le Point des Connaissances Actuelles.* *By Henri V. Vallois. Presses Universitaires de France, Paris.* 15 fr. (paper). 128 pp.; ill. 1944.

This competent little booklet, destined primarily for the layman, is foremost a survey of human races by continents. Subdivisions are much the same as with other French standard authors. Vallois counts 27 races as compared to Deniker's 29 and Lester's 21. Discussion is most interesting when dealing with Africa, a field of special interest to the French as well as to the author. It should be duly emphasized that the useful little book, although published during the German occupation, makes no concessions or bows to the antiscientific race myth, not limited to, but with particular energy cultivated by, the Nazis.

E. H. ACKERKNECHT

RACES, LANDS, AND FOOD. *A Program for World Subsistence.* *By Radhakamal Mukerjee; introduction by Harold L. Ickes. The Dryden Press, New York.* $2.25. vi + 107 pp.; maps. 1946.

In this little book R. Mukerjee has briefly summarized the data showing the increasing need for food and the growth of the populations of South and East Asia.

He makes an excellent case for their great need of more land and larger resources, as an essential for improvement in their level of living. He then points out that there are relatively large areas of unused or inadequately used lands in many parts of the world, especially in the tropics, which these Asiatic peoples could use to great advantage. At present the Europeans, although they have had ample opportunity during the past century to settle them and use them, have shown no aptitude for such colonization. Hence he demands that these lands be opened up to the crowded and growing peoples of South and East Asia, and that they be aided in settling and developing them in order to improve their level of living. He believes that only in this way can a start be made toward equalizing economic conditions between that part of the world and the West.

Although some of the facts Mukerjee uses are a little out of date, they are essentially accurate and do not distort the true picture. His interpretation of these facts also seems sound. The shift in rapid population growth from the West to the East and the growing awareness by the East of the discriminations practised against it in gaining access to the world's resources are bound to make trouble if they persist. Already there is great resentment, which will grow rapidly in the future and will increase political instability in that region.

At several points in his discussion Mukerjee seems to support the view that freedom to migrate would solve the economic problems of South and East Asia, as well as remove the bitterness which has long been accumulating against the Europeans. The reviewer must disagree to a certain extent with this view, not because he does not want to see barriers to migration removed as fast as possible, but because he believes that much racial and national antagonism arises out of economic struggles and that free migration will not remove many of the economic causes of friction. To me the capacity for growth of the more than one billion people in South and East Asia seems to be such that no imaginable migratory movement could possibly do much to relieve the increasing population pressures in this region, except for local areas and for short periods. However, it does seem likely that the right to migrate to the unused or little used areas of the tropics might go far to lessen the bitterness of these peoples toward the Europeans who now prevent such migration. In other words, *freedom* to migrate would do far more to relieve the psychological pressure than actual migration to relieve the economic pressure.

Mukerjee would probably not deny this, because he recognizes clearly the Malthusian character of the population problem in this region, and that good levels of living can only be attained if and when these peoples are able and willing to control their births. At times, however, he seems to forget this in his eagerness to point out the injustices of that present distribution of resources in the world for which the European colonial powers are chiefly responsible.

The reviewer is on record long ago (*Danger Spots in World Population*, 1929) as agreeing in essence with Mukerjee's diagnosis of the dangers inherent in the population pressures building up in South and East Asia, but he believes they are only in part due to the "dog-in-the-manger" attitudes of the European Colonial powers. Hence, he is less optimistic than Mukerjee that migration will do much to solve the economic problems of these peoples until they learn to control their births to about the same extent as the peoples of western Europe. How can agriculture be improved, or where can room be found, or whence will spring the industry to provide for the increase of twelve to fifteen million annually which could easily be produced by the billion people now living in South and East Asia?

WARREN S. THOMPSON

LES CLIMATS ET L'ORGANISME HUMAIN. *"Que Sais-Je?" Le Point des Connaissances Actuelles.* *By Emile Dubot. Presses Universitaires de France, Paris.* Paper. 127 pp. 1945.

The author starts by making a lucid survey of the different elements of climate (impurities of the air, radiations, temperature, humidity, pressure, etc.) and of the geographical factors that determine certain combinations of these elements (latitude, altitude, etc.). As Dubot is professor of medicine in Lille, it is natural that he views the relations between climate and the human organism rather from the angle of pathology and therapy than from that of normal physiology. He discusses extensively what role the elements and different types of climate (regarding quite rightly the "urban climate" as a special type) may play in the causation or evolution of diseases (mental diseases included). In a second part, the author reviews the therapeutic possibilities of the different elements and types of climate, with special reference to the different regions of France. The book is mainly based on French and other European research. American material is hardly ever mentioned. It is a pity that the popular character of this little book did not allow for detailed references, because otherwise it is a most valuable introduction into the field of climatopathology and therapy, and is outstanding for its sobriety and critical sense.

E. H. ACKERKNECHT

HUMAN BREEDING AND SURVIVAL: *Population Roads to Peace or War. Pelican Books. Revised Edition.* *By Guy Irving Burch and Elmer Pendell; foreword and*

postscript by Walter B. Pitkin. Penguin Books, New York. 25 cents (paper). vi + 138 pp. 1947. A Pelican edition of the book reviewed in Q. R. B. 21: 128; March, 1946.

BIOMETRY

INTRODUCTION TO STATISTICS. *Revised.* *By Charles C. Wagner, Evan Johnson, Jr., Beatrice L. Hagen, and Clyde H. Graves. Published by the authors, The Pennsylvania State College; J. W. Edwards, Ann Arbor, Michigan.* $1.75 (paper). iv + 139 pp. 1946.

This book, as its title implies, is an introduction to elementary statistics. It has ten chapters, headed as follows: Introduction, Frequency Tables and Graphs, The Arithmetic Mean and Standard Deviation, Other Methods of Analyzing Data (median, mode, geometric and harmonic means), Probability, The Normal Curve, Theory of Sampling, Skewness and Kurtosis, The Line of Best Fit, and Correlation. A table of areas and ordinates of the normal curve is given in an appendix. The contents are mainly concerned with descriptive statistics. The one chapter on sampling goes no farther than to show how the difference between two means is tested for significance.

This is a pretty good little book—as far as it goes. The mathematical derivations are easy to follow, it is liberally interspersed with problems, enough answers to the problems are given so that a student may check his computations, and the problems are eclectic—not chosen from one field of science, as is so frequently the case.

But the reviewer's problem is this: To whom should he recommend such a book? It is much too brief for a semester course in statistics. It certainly will not satisfy the research worker—even if he uses statistics only occasionally—because the book ends without covering most of the important formulae the research man needs, viz., the reliability and sampling statistics. Perhaps its chief usefulness will be for those individuals who know nothing about statistics and want to learn a little about it by themselves. But even then, the reviewer can think of several other introductory texts which are more complete than this one and no more difficult.

A. CHAPANIS

MULTIPLE-FACTOR ANALYSIS: *A Development and Expansion of "The Vectors of Mind."* *By L. L. Thurstone. The University of Chicago Press, Chicago.* $7.50. xx + 535 pp.; ill. 1947.

Thurstone's *Vectors of Mind* was first printed in 1935, was reprinted twice and is out of print again. Although the present volume contains essentially all the material of this earlier work, much has been added in multiple-factor theory. Simple structure, communality, the oblique reference frame, and other concepts are expanded and treated more comprehensively. New factorial methods permit the solution of rotational problems and factorial problems which were prohibitive ten years ago. This is essentially a theoretical treatment, however; detailed computational routine has not been featured, since it will be covered in a work-book on multiple-factor analysis now in preparation.

Multiple-factor analysis is a statistical "specialty" used in the analysis of matrices of correlation coefficients. It has been used mainly in the analysis of certain types of psychological data, although its usefulness is by no means limited to this discipline. Thurstone's treatment of factor analysis as a general scientific method is very well done, and his use of mechanical and geometrical examples aids considerably in illustrating several points. But the reader must not be misled: this is a technique for the statistical or mathematical expert. For such experts who are interested in factor analysis, this book is required reading. Others will do well to leave it alone.

A. CHAPANIS

DE OMNIBUS REBUS ET QUIBUSDEM ALIIS

PATTERNS FROM NATURE. *Photographs by Horst. J. J. Augustin, New York.* $10.00. xii + 108 pp. 1946.

"This book is an attempt to show, through the eye of the camera, a few of the basic elements of form existing in Nature." "For the most part, the pictures found here [are] of common objects daily passing before our eyes. Nothing has been added to enhance them. They are photographed without artificial arrangements and special effects, in their own setting and in their proper light. Direct or diffused sunlight coming from above caresses their surface and in some instances dew or rain brings into relief their fine texture" (author's Foreword).

The one hundred photographs selected reproduce, with the elimination of color, the pattern, form, almost the very texture, of plant foliage, bark, or flower, of crystalline mineral, mollusk shell, or butterfly wing. Often a curious affinity of pattern is seen to emerge from objects of totally different nature. Often, too, the close, somewhat magnified view of the camera, or a simple transection of the object, lays bare unsuspected or concealed patterns of form and structure.

The large plates, most of them 9 x 11½" in size, are superbly printed. Plant foliage so predominates

among the subjects that one might wish that there had been either a greater restriction, to that one group of patterns alone, or else that a far wider and more representative choice of subjects had been made.

Perhaps the last ten plates are most interesting of all. Here a square unit of pattern from one of the earlier subjects has been taken and repeated sixteen times in antithetic juxtaposition, so as to form a large square. Like those of elaborate veneers, patterns are thus achieved that express a recurrent rhythm and harmony throughout their infinite intricacies of detail. Some of the results are simply bizarre; others acquire unexpected loveliness.

BENTLEY GLASS

SONORA SKETCH BOOK.

By John W. Hilton. The Macmillan Company, New York. $5.00. xii + 335 pp.; text ill. 1947.

The biologist whose interests have led him to study life in the field will enjoy this book—not so much, however, for the actual biology it contains as for the anecdotes which will recall memories of former expeditions and supplement their experiences. Hilton has a lively interest in people and country, an interest which he has succeeded in blending with his own artistic abilities to an extent that conveys a real picture of travel in Sonora. Although primarily concerned with people, Hilton has recorded many observations of interest to the naturalist, such as accounts of finding a rich Pleistocene fossil bed, of the antics of jumping beans, of collecting birds, and of the discovery of a population of rare fresh-water crabs.

The book is well illustrated by sketches of a variety of subjects executed by the author during his travels in Sonora. These sketches add much to the value of his presentation.

JOHN E. CUSHING

BLUE ANGELS AND WHALES: *A Record of Personal Experiences Below and Above Water.*

By Robert Gibbings. E. P. Dutton & Company, New York. $3.00. 153 pp.; ill. 1946.

Originally published several years ago as a Penguin Book, this artist's-eye view of marine biology in tropical waters has been expanded for this more permanent edition. Being an artist with both pencil and words, and an Irishman with a fondness for anecdote to boot, Gibbings writes a delightful melange of biology, mythology, and travellers' tales. There are vivid descriptions of the life of coral reefs, amusing views of shipmates, and sound observations on the coloration of marine animals. Gibbings has delved into all sorts of references, from sober systematic treatises to well-known books, but he has made this material his own, lacing it gracefully into the record of his own experiences. Some readers may find this little more than "a book about fishes by a man with a beard"; others will find it an amiable synthesis of science, art, and literature. Like the author's other books, *Blue Angels and Whales* reveals the charm of a personality few can resist.

JOEL W. HEDGPETH

A HISTORY OF SCIENTIFIC ENGLISH. *The Story of its Evolution Based on a Study of Biomedical Terminology. By Edmund Andrews. Richard R. Smith, New York.* $7.50. x + 342 pp.; ill. 1947.

A title more truly descriptive of its contents should have been chosen for this volume, compiled by a busy doctor in moments snatched from surgical practice and teaching. It is a book about words, with special attention to the origin and growth of medical terminology. Considered as a group of essays or lectures that evolved from a central interest in etymology and are served up without documentation for the stimulation of the general educated public, the book has appeal and should prove provocative. Its information has been assembled entertainingly from a variety of trustworthy sources, but it is neither presented nor elaborated in strict historical sequence, nor does the material cover to any degree the entire field of scientific English.

An introductory section sketching the background of Indo-European philology and semantic changes leads to a consideration of the author's main theme, the history of medical terminology, which is then developed with variations in a series of chapters that deal with pre-Hellenic influences, the Aryan heritage, and the contributions of Greek, Latin, Arabic, French, and German. In three chapters devoted to the development of English, specific medical words become for a time somewhat sidetracked because of the author's absorption in the whole problem of how Anglo-Saxon was transformed by astonishing amalgamation into modern English. Scientific English, he points out, is now 95 per cent foreign, an international blend with a negligible percentage of Anglo-Saxon "idea words" amid a tangle of Greek, Latin, French, and other derivatives. The medical vocabulary grows constantly to keep pace with technical invention and advances in medical research. Medical dictionaries become increasingly un-English. Dictionary editions become quickly outdated because thousands of new words must be added. New words, coinages, lean heavily upon Greek, partly because many Greek prefixes and suffixes have already been assimilated into English. The language of science stands "apart and above real spoken language" and is based "not upon verbal intercourse but study of the printed word." It is

international in character and should be changed only for the sake of furthering its internationality.

Unexpectedly, in the last chapter of the book, Andrews has composed an entire section in Basic English. This use serves as an ingenious plea for the adoption of this new development of English as a common future language for all planes of science. It is a logical choice, since English today is the most widely used modern language, known as a "second language" by practically every scholar in Europe and the Orient. Those who do not know classic English could easily master the 850 word vocabulary which is all that Basic English requires.

The unexpected appearance of this argument is arresting, and characteristic of Andrews as an author. In the midst of his discussions on the development of medical terminology, he has inserted a chapter on Science vs. Vulgarity that develops the case of "many words of respectable and ancient lineage today under tabu," and recalls Henry Mencken's essay on the relative respectability of the organs of the human body. Another instance of original approach occurs in an earlier chapter, where Andrews has skillfully sharpened an account of his personal observations of South Sea culture and languages among the Polynesians by a novel comparison at every stage with the historic development of society and speech in Greece.

An excellent bibliography and a well-developed index enhance the value of this volume.

BETSY C. CORNER

THE YALE COLLECTIONS.

By Wilmarth S. Lewis. Yale University Press, New Haven; Geoffrey Cumberlege, Oxford University Press, London. $2.00. xvi + 54 pp. + 13 plates. 1946.

This beautifully printed book describes the Yale University Library, Art Gallery, the Peabody Museum, and the Anthropology Museum. Biologists will be particularly interested in the account of the growth of the great Peabody Museum collections especially through the work of Othniel C. Marsh, Charles E. Beecher, Charles Schuchert, Carl O. Dunbar, and George R. Wieland —work which has made the museum world-renowned for its collections of fossils of vertebrates, trilobites, brachiopods, and fusulines, among animals, and of cycads among plants. The collections of modern forms have been enriched through the labors of A. E. Verrill in collecting marine invertebrates and of Alexander Petrunkevitch in collecting spiders.

The archeological collections are especially strong in eleven regions: Oregon, Southern California, the Mississippi Valley, Connecticut, Panama, the West Indies, Venezuela, Peru, India, Belgium, France, Switzerland, and North and East Africa. The ethnological collections are concentrated on the Arctic Indians, the Plains Indians, China, and Melanesia. The Indian collections, like the paleontological ones, owe a great deal to the indefatigable zeal of Marsh. The anthropological materials are strong in Connecticut, Oregon, Peru and Hawaii. There is a great need for an adequate building for these collections. The Peabody Museum at present houses about half of them, the rest being scattered. Only a small fraction of the suitable objects can be displayed.

BENTLEY GLASS

MAN AND HIS PHYSICAL WORLD. *Second Edition. By Dwight E. Gray. D. Van Nostrand Company, New York.* $4.25. xii + 699 pp. + 1 plate; text ill. 1946.

This up-to-date elementary textbook of physical science is complete in its coverage of general physical fields and is excellent in its interrelation of scientific method and the historical development of scientific knowledge to the basic knowledge obtained and to the technological and social applications of that knowledge to human life. From the point of view of a biologist, it fails only in relating physical to biological phenomena. There has been almost no attempt to do this. Sound is sound without an ear; high polymers are synthetic plastics but proteins are ignored; the atmosphere is composed of nitrogen, oxygen, and carbon dioxide, etc., without reference to living organisms. There are a few exceptions. The human eye and theories of color vision are discussed in connection with light. Rubber is chosen as an example of a colloid—but without reference to the overwhelmingly colloidal nature of all living matter. There is, in particular, a very useful chapter on geological history and the relation of geological and climatic changes to fossil history. But biochemistry and biophysics are in general neglected, and the chapters on mathematical tools ignore statistics.

Of course it may be said that everything cannot be included, and that the selection of material by the authors has been a matter of deliberate choice. The point of the criticism is, then, not that the book is not a good textbook of physical science per se, but rather that it is not particularly suited for reference and study by those students and teachers who are primarily interested in biological concepts and relations.

BENTLEY GLASS

HOYER-KREUTER TECHNOLOGISCHES WÖRTERBUCH. *Erster Band. Deutsch-Englisch-Französisch. (Volume II. English, French, German. Volume III. French, German, English.)*

Edited by Alfred Schlomann. (Julius Springer, Berlin); Frederick Ungar Publishing Company, New York. $50.00. x + 795 pp. (1932); 1944.

Under the authority of the Alien Property Custodian, the great three-volume Hoyer-Kreuter technological dictionary, in the sixth edition, has now been made available in the United States. The printing is much superior to that in most books reproduced by the photo-offset process. Volume I gives English and French equivalents for the alphabetized German terms; volume II gives the French and German equivalents for English terms; volume III gives the German and English equivalents for French terms. The vocabulary is general and technological. Technical biological words are not included, except in such fields as medical and sanitary engineering, agriculture, forestry, and foodstuffs; and even the vocabulary of the physical sciences is somewhat limited. Translators of scientific works, however, will find these volumes valuable.

THE BACONIAN LECTURES ON AIMS AND PROGRESS OF RESEARCH IN THE STATE UNIVERSITY OF IOWA 1945. *General Theme: Global Trends in Research. Series on Aims and Progress of Research Number 80, Study Series Number 415.*

[By Carl E. Seashore and others]. University of Iowa, Iowa City. $1.00 (paper). 121 pp. 1946.

This publication contains a number of short lectures on university research, addressed to the general public, and of an elementary nature. They include: Introduction, by Carl E. Seashore; Research in Biological Sciences, by Joseph Hall Bodine; in Chemistry, George H. Coleman; in History, W. T. Root; in Language, Erich Funke; in Economic Science, George R. Davies; in Applied Arts, Lester D. Longman; in Engineering, Ralph M. Barnes; in Psychiatry, P. E. Huston; in Child Welfare, Robert R. Sears; in Medicine, P. C. Jeans. Biologists will be most interested in the non-biological contributions, inasmuch as they will find nothing new to them in the lectures on biological subjects. In general, the series resembles those Talks on Science given over the radio during the intermissions of the New York Philharmonic Orchestra broadcasts, although the Iowa series covers a broader variety of fields.

BENTLEY GLASS

SCIENCE YEAR BOOK OF 1947.

Edited with an introduction by J. D. Ratcliff. Doubleday & Company, Garden City. $2.50. xxxvi + 247 pp. 1947.

Ratcliff's excellent year book follows the pattern of previous years, the selections being grouped into five parts: Physics and Chemistry; Medical Research; Agriculture; Aviation; and Other Sciences. The editor's own Introduction, which fills in some of the gaps, is quite the best article of them all. In general, the practice of drawing upon the current popular magazines for scientific articles leads to a certain degree of superficiality and over-magnification of the marvels of scientific achievement. Sensational new claims are accepted at face value before adequate tests have been carried out. Ratcliff is to be commended for having avoided as much of that sort of thing as he has, by judicious selection; yet even so, one gets a bit tired of the purple prose before finishing. A study of the scientific writing done for the layman by our British friends in the Penguin-produced *Science News* and *New Biology* series ought to profit the editor, and particularly the writers, of the *Science Year Book of 1947.*

Of biological interest are the following contributions: Atomic Energy in Medicine, by Robley D. Evans (Atlantic Monthly); New Weapon against Death, by Wm. L. Laurence (Ladies' Home Journal); Brain Surgery for Blue Babies, by Lawrence Drake (Collier's); They Get Up and Live, by Miriam Zeller Gross (Sat. Evening Post); Medicine from the Earth (Fortune); Bacterial Warfare, by Sidney Shalett (Collier's); War on Flying Microbes, by Steven M. Spencer (Sat. Evening Post); Cornered Killer, by Bill Davidson (Collier's); New Facts about Tooth Decay, by Arnold Nicholson (Sat. Evening Post); Exploring the Mind, by Francis Sill Wickware (Cosmopolitan); We Can Farm the Oceans, by Harold F. Clark and George T. Renner (Sat. Evening Post); Facts about DDT (Fortune); Silk: Made in America, by Edw. D. Radin (Cosmopolitan); Extra-sensory Perception, by J. B. Rhine (American Magazine); The Lost Americans, by Frank C. Hibben, from the book of that title. Such titles are not always informative: the "new weapon against death" turns out to be the Russian ACS serum; "get up and live" concerns the new post-operative technique of encouraging movement and walking as soon as possible; "cornered killer" is angina pectoris; etc. Probably every reader, even among professional biologists, will glean much that is new and interesting to him from these pages. The popular science writers, aside from their irrepressible desire to play up their subjects, are clear and accurate reporters. The biologist will supply his own critical judgment, but what of the lay public who will be the chief readers of this book?

BENTLEY GLASS

PROCEEDINGS OF THE PACIFIC SCIENCE CONFERENCE OF THE NATIONAL RESEARCH COUNCIL *Held at National Academy of Sciences, Washington, D. C., June 6–8, 1946. Bulletin of the National Research Council Number 114.*

Published by the National Research Council, National Academy of Sciences, Washington, D. C. 50 cents (paper). x + 79 pp. 1946.

All biologists will be interested in these Proceedings of the conference which recommended to the National Research Council the establishment of the Pacific Science Survey, with divisions of Anthropological Sciences, Earth Sciences, Oceanography and Meteorology, Plant Sciences, Public Health and Medicine, and Zoological Sciences. Specific recommendations for scientific study were made within each of these divisions, and general recommendations were added as to declassification, conservation, fellowships, the Pacific War Memorial Foundation, field stations, science appraisal, documentation centers, internships, assistance in the organization of the Pacific Congress, check lists of flora and fauna, descriptive geography of Micronesia, scientific appraisal at Bikini, etc. Special attention was also paid to the need for and great desirability of international cooperation in all these regards.

PACIFIC SCIENCE: *A Quarterly Devoted to the Biological and Physical Sciences of the Pacific Region. Nos. 1, 2. January, April, 1947.*

Edited by A. Grove Day. The University of Hawaii, Honolulu. $3.00 a year; single copies, $1.00.

The second issue (first not seen) contains the following papers: Parasites and Parasitic Diseases of Domestic Animals in the Hawaiian Islands (Joseph E. Alicata); Fault at Waimea, Oahu (Harold S. Palmer); Fungi of the Marshall Islands, Central Pacific Ocean (Donald P. Rogers); A Chloride and Oxygen Analysis Kit for Pond Waters (R. B. Dean and R. L. Hawley); A New Species of Carex (Cyperaceae) from Fiji (Harold St. John); Notes: Facilities for Research in the Natural Sciences in the Hawaiian Islands.

The paper and printing (two columns) are good. Half-tones, however, are printed on regular stock, not a policy conducive to good reproduction.

UNIVERSITY OF COLORADO STUDIES. *Series D. Physical and Biological Sciences. Volume 2, Number 3.*

University of Colorado, Boulder. $1.00 (paper). Pp. 295–403. 1947.

This number contains the following articles on biological subjects: Production of variants of the *Escherichia* and *Aerobacter* genera in different media, by Joseph J. Tregoning and Charles F. Poe; Use of some organic acids in media for the separation of the *Escherichia* and *Aerobacter* genera of bacteria, by William E. Clapper and Charles F. Poe; Effect of low temperature on the vitamin A content of carrots, by Charles F. Poe and Ola K. Gant; Vitamin B_2 (G) content of Chinese Cabbage, by Charles F. Poe; Note on the effect of certain agricultural conditions upon the mineral contents of wheat, by G. Wakeham; Keys to aquatic insects of Colorado, by Robert W. Pennak; Altitudinal indicators among the Formicidae, by Robert E. Gregg.

THE UNIVERSITY OF COLORADO STUDIES. *General Series (A). Volume 27, Number 4.*

University of Colorado, Boulder. $1.00 (paper). 120 pp. 1946.

This number contains an article of biological interest: Modern Biology and the Origin of Species, by Gordon Alexander; pp. 17–31.

SOME BRITISH BOOKS ON AGRICULTURE, NUTRITION, FORESTRY AND RELATED SCIENCES 1939–1945. *Imperial Agricultural Bureaux Joint Publication Number 11.*

Compiled by H. M. Bedington. Imperial Agricultural Bureaux, Central Sales Branch, Penglais, Aberystwyth, Great Britain. 3s. (paper). v + 37 pp. 1946.

This useful bibliography lists alphabetically by author, and indexes by subject 396 British biological books published in the years 1939–1945. Study of the list may reveal a number which have been overlooked by Americans because of war conditions. The list is completed by the addition of the publications of the Imperial Agricultural Bureaux, with directions for ordering them.

CARNEGIE INSTITUTION OF WASHINGTON YEAR BOOK *Number 45, July 1, 1945–June 30, 1946, With Administrative Reports through December 13, 1946.*

Carnegie Institution of Washington, Washington, D. C. $1.50 (cloth); $1.00 (paper). xxxiv + 235 pp. 1946.

In addition to the annual reports of the Carnegie Institution for the year 1945–1946, the Year Book contains a survey of work in progress by the investigators at the various departments which is always very interesting. At Stanford University the study of antibacterial substances isolated from *Chlorella* is progressing to the point of chemical identification of some of them as fatty acids having an average chain length of eleven carbon atoms. Further studies of photosynthesis, of the chemical composition of *Chlorella*, of climatic races of the yarrow *Achillea*, and of the hybrids of *Poa* species are also being made. Chaney's studies at Berkeley of the Mascall and later Miocene floras and of the Oligocene Florissant flora are also going forward.

At the Department of Embryology in Baltimore, work is being done on the physiology of the pregnant uterus, on placental transmission, on the early stages of human development, on the effects of sex hormones upon the development of the embryonic urinogenital system in opossums, on oxidative enzymes in the fetal brain, on strain differences in response to carcinogens in rats, on the induction of immunity to malignant tumors and the retardation of sarcomata by Nile blue in rats, on the reproductive cycle in the baboon, and other problems. At the Department of Genetics at Cold Spring Harbor, work is progressing upon a number of studies on the nature and action of genic substances. New unstable mutants in maize; the causes of inviability of interspecific hybrid embryos in cotton; chromosome and cellular changes in mouse leukemia; the action of infrared radiation in conjunction with x-rays in producing mutations and chromosome breakage in *Drosophila;* cyclic fluctuations in the frequency of particular chromosomes in *Drosophila;* the induction of mutations in *Drosophila* by chemicals in aerosols; the origin of bacterial resistance to streptomycin and penicillin by mutation; the relation of the dosage of x-rays and ultraviolet rays to the induction of mutations in bacteria; and cytological studies of bacteria and bacteriophage growth—these are some of the problems reported upon. Important preliminary reports upon some of this work are published here.

BENTLEY GLASS

ANNUAL REPORT OF THE BOARD OF REGENTS OF THE SMITHSONIAN INSTITUTION *Showing the Operations, Expenditures, and Condition of the Institution for the Year Ended June 30, 1945. Publication 3817.*

United States Government Printing Office, Washington, D. C. $1.75. iv + 484 pp. + 80 plates, 2 maps, 1 figure. 1946.

In addition to the usual reports of the year's activities (July 1, 1944 to June 30, 1945) of the branches of the Smithsonian Institution, the Yearbook contains the General Appendix, a collection of miscellaneous papers summarizing progress in a variety of scientific fields. Scientists who are not aware of, or who fail to make use of, this annual section, are missing an exceptional opportunity. Nowhere else can one get so varied, authoritative, and non-technical a survey of scientific progress—and so inexpensively, it may be added (compare the cost, for example, with that of the similar *Science in Progress* series, at $5.00 per volume). Teachers will find the reviews excellent for assignment to students, from the high school level up.

The broadly biological subjects treated are as follows: Medical uses of the cyclotron, by F. G. Spear; Conserving endangered wildlife species, by Hartley H. T. Jackson: Living with the boll weevil for fifty yeers, by U. C. Loftin; The indispensable honeybee, by James I. Hambleton; The importance of plants, by W. J. Robbins; Fungi and modern affairs,by J. Ramsbottom; The introduction of abacá (Manila hemp) into the Western hemisphere, by H. T. Edwards; Growing rubber in California, by E. L. Perry; Thinking about race, by S. L. Washburn; A unique prehistoric irrigation project, by Henry C. Shetrone; Concepts of the sun among American Indians, by M. W. Stirling; Human problems in military aviation, by Detlev Bronk; Blood and blood derivatives, by Edwin J. Cohn; The microbiotics, by John N. McDonnell; and a brief summary of the Smithsonian Institution's part in World War II.

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